FISHERY RESEARCH

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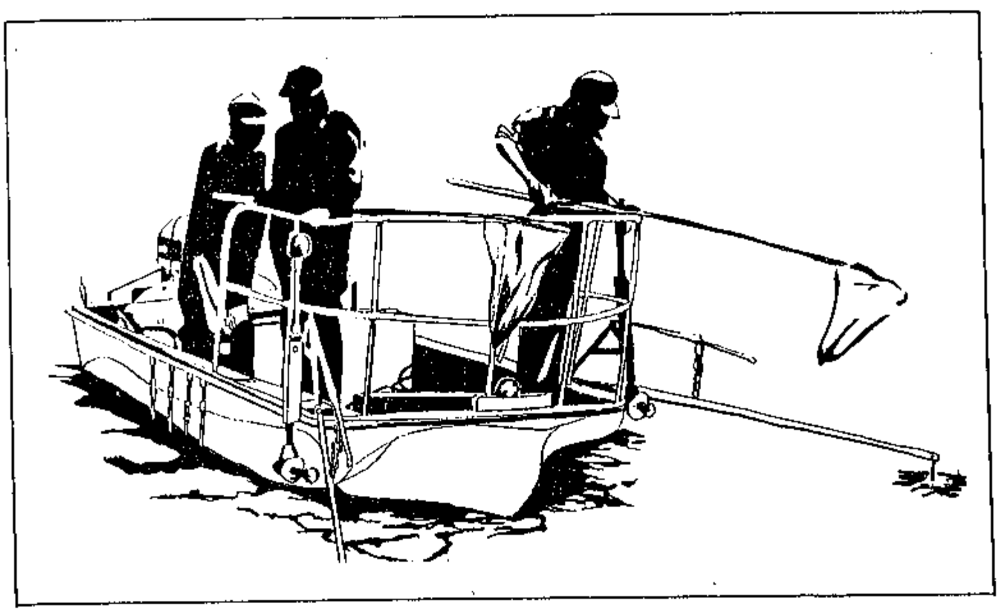
Job Completion Report, Project F-73-R-5
Subproject III: Lake and Reservoir Investigations
Study VII: Largemouth Bass Investigations



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November, 1983

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JOB PERFORMANCE REPORT

State of Idaho

Name: Lake and Reservoir Investigations

Project No. F-73-R-5

Title: Largemouth Bass Investigations

Subproject III

Study No. VII

Job No. I

Period Covered: 1 March 1982 - 28 February 1983

ABSTRACT

Research on largemouth bass in north Idaho lakes was initiated in 1981 and maintained during 1982. Six lakes, including five in the Coeur d'Alene River lateral lake system, and Fernan Lake on the outskirts of Coeur d'Alene were selected as primary study lakes. Five other lakes were sampled on a cursory basis. On select lakes, angler effort, harvest, and yield was estimated by creel census. Data on growth, mortality, exploitation, and population structure and size was collected through electrofishing and tagging. The potential effects of exploitation and regulation changes on population structure and yield were explored with an equilibrium yield model. The relative impact of tournament fishing and displacement was evaluated at several major bass tournaments.

Total angling effort ranged from 1,900 hours during the season on Swan Lake to 55,400 hours on Fernan. Angling pressure ranged from 6.4 hours/ha on Swan to 382 hours/ha on Fernan. Fishing pressure by bass anglers ranged from 5.1 to 43.4 hours/ha on the same two lakes.

Total catch and harvest rates were generally similar among lakes but harvest of large bass and yield to the angler were significantly lower in Fernan and Blue Lakes than the others.

Much of the difference in quality of fishing was due to stock structure. High mortality and slow growth were major factors regulating the population composition in Fernan Lake.

Estimated exploitation on the study lakes was high, ranging from 48% to 78%. Mortality due to fishing was, by far, the major loss in these populations. Data indicate that total mortality has been increasing in recent years, and results of the yield model indicate that abundance of large fish will decline in most lakes.

A 305 mm size limit could provide a significant benefit in yield and stock structure in most lakes. More restrictive regulations such as a 356 mmm size limit, early season closure, or complete catch-and-release fishing may be necessary to maintain or enhance numbers of large bass. Anglers indicated strong support for more restrictive regulations.

Several major bass tournaments did not have a significant negative effect on individual populations. Displaced bass did not show a strong homing tendency, however, and tournament fishing must be considered as harvest from individual populations even though hook-and-release mortality was low.

Recommendations for evaluation of other bass populations are included.

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INTRODUCTION

Largemouth bass (Micropterus salmoides) populations in north Idaho have provided high-quality fishing in the past and large fish have been common in the catch. Historically, these populations have been relatively lightly exploited, but interest in bass fishing is increasing rapidly. Several bass fishing tournaments are now held in north Idaho each year. Local anglers have become concerned and vocal about declining fisheries. Our current knowledge of these populations is limited. It is apparent, however, that growth rates are low, probably due to relatively low water temperatures and a short growing season (Goodnight 1980). Slow growth rates could make these populations more vulnerable to exploitation than those found in more typical largemouth habitat. Idaho's bass regulations are fairly liberal and may not be adequate for maintenance of strong populations. Elsewhere, restrictive regulations have been used successfully to maintain or enhance the quality of fishing on bass populations susceptible to overharvest. Such regulations have also failed in many instances, resulting in no improvement in fishing quality, a reduced yield, or a stunted, out-of-balance fish community. Adequate knowledge of population dynamics and the relative importance of exploitation and other limiting factors is necessary to provide effective regulation and optimum utilization of these fisheries.

This project was designed to examine the effects, both current and potential, of exploitation on north Idaho bass. To do that, the Coeur d'Alene River lateral lake system (Fig. 1) was selected as a study area. The lakes are similar in size, trophic condition, and morphometry and are in close proximity to one another. All of the lakes are known to sustain healthy bass populations. The lakes do differ in access and resultant fishing pressure. The proximity of the lakes makes it possible to work on several lakes at one time. By selecting lakes that show a range in fishing pressure, it is possible to examine population dynamics of stocks experiencing different levels of exploitation. Fernan Lake, on the edge of the City of Coeur d'Alene, has also been included in the study. Fernan is similar to the lateral lakes in size and trophic status and sustains an important bass fishery. Fernan does, however, experience extremely high fishing pressure due to its urban location. The inclusion of Fernan in the study can provide data on a bass population experiencing very high exploitation.

Bass populations in other northern Idaho lakes have been included on a cursory basis as time permits. The lakes selected as primary study areas ranged in size from 94 to 295 hectares in surface area (Table 1). Conductance in each lake ranged from 50 to 75 µmhos. Each lake contains a variety of habitat, including steep rocky shoreline and large expanses of shallow marsh area. All are considered to have excellent habitat for largemouth bass.

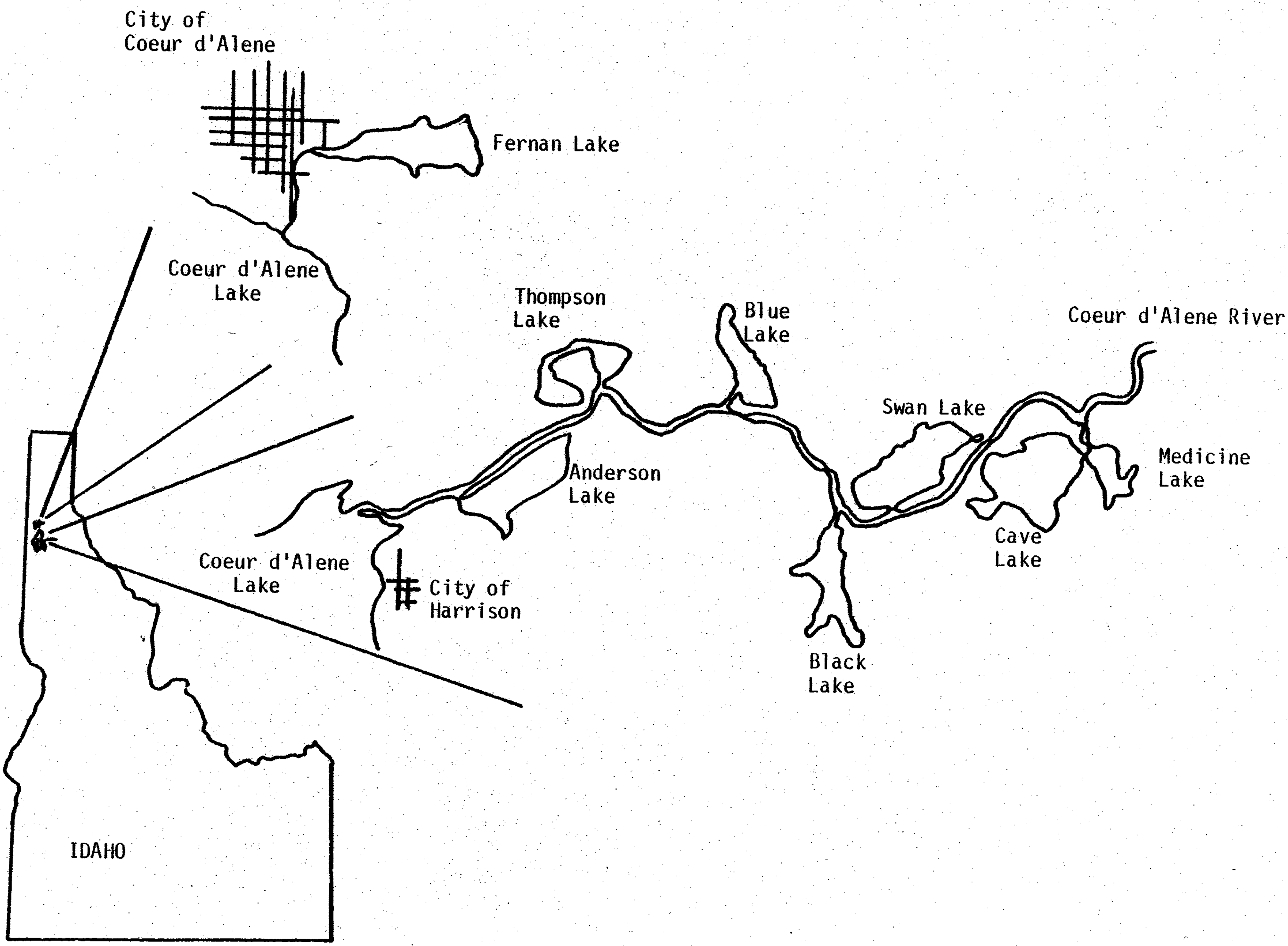
City of
Coeur d'Alene
Fernan Lake
Coeur d'Alene
Lake
Thompson
Lake
Blue
Lake
Coeur d'Alene River
Swan Lake
Medicine
Lake
Anderson
Lake
Cave
Lake
Coeur d'Alene
Lake
City of
Harrison
Black
Lake
IDAHO

Table 1. Surface area of selected North Idaho lakes.

Lake	Surface Area (hectares)
Fernan	145
Thompson	205
Anderson	201
Blue	136
Swan	295
Medicine	94

The primary goals of this project are to describe the dynamics of separate populations and their relationship with the fisheries and exploitation. A separate project, undertaken as graduate research and funded by the Washington Water Power Company, is directed at describing recruitment of juvenile bass and at exploring factors that may regulate or limit that recruitment (Bowles in preparation). A thorough description of the lakes, their relative productivity, morphometry, habitat characteristics, and associated fish communities will be available in that work.

The ultimate goals of this program are to provide management alternatives and a system for monitoring these and other populations. A simple modeling approach is used to evaluate regulations and population responses. It is hoped that a generalized management program can be developed from this work for all Idaho populations.

Tournament fishing has become common in northern Idaho in recent years. Currently, several major tournaments are held annually on the Coeur d'Alene Lake system. Typically, tournament-caught bass are released alive, but may be displaced a considerable distance from their point, or in the case of the lateral lake system, lake of origin. Because very little is known about the homing ability of largemouth, the impact of tournament fishing on individual populations in lakes of the Coeur d'Alene system is a concern. Due to the growing interest in tournament fishing and concern of local sportsmen, an evaluation of tournament harvest and the effects of displacement has been included in this project.

OBJECTIVES

To describe age composition and growth of largemouth bass populations in selected north Idaho lakes.

To estimate bass fishing effort and exploitation on selected lakes and describe the effects of exploitation on population structure.

To describe the impact of major bass tournaments on the Coeur d'Alene system.

To define fisheries management alternatives for north Idaho bass populations.

RECOMMENDATIONS

1. Exploitation appears to be relatively high on all of our study lakes. Analysis indicates that population structure and quality of fishing may decline at current or increased levels of exploitation. Data on other lakes in northern Idaho is limited, but suggest that growth is low and mortality may also be relatively high. A 305 mm (12") size limit could provide significant benefit and should be considered as standard regulation for north Idaho waters. Additional data on lakes not included in the study should be gathered in this consideration.

2. The Coeur d'Alene Lake system is an important area for anglers specifically seeking bass. Many anglers are interested in "quality fishing" for large fish. A 305 mm size limit may improve the yield on some of these lakes, but will do little to maintain or enhance the numbers of large fish. Several lakes could be selected as quality fishing waters with more restrictive regulations. A 356 mm (or larger) size limit and/or a partial season closure should be considered for select waters.

3. Blue Lake appears to have a depressed bass population. Fishing pressure on Blue is applied primarily by bass fishermen. A closure to bass harvest (catch-and-release) could be a useful and acceptable regulation for any attempt to rehabilitate that population. Depending on the results of the tournament transplant experiments, introduction of tournament-caught fish could also be considered as a rehabilitation measure.

4. If more restrictive regulations are imposed, an evaluation of population responses should be conducted two or three years following the regulation change. A partial season closure to harvest could result in unusually heavy fishing pressure following the opening of a harvest season. If a partial season closure is instituted, an evaluation of the change in fishing pressure prior to and following the period of catch-and-release fishing should be conducted in the year of regulation change. A periodic angler count would be adequate.

5. The transplantation of tournament-caught bass could be a useful tool for the rehabilitation of lakes that have been over-fished or have problems in balance of predators and forage. The relative contribution to the population and impact on the forage base of 1982 transplants should be evaluated. Future transplants should not be encouraged during periods of high water temperature.

6. Exploitation estimates are critically important data for management decisions. Estimates based on population and harvest estimates are expensive, time consuming, and relatively imprecise. Tag return estimates offer more precision and efficiency, but are biased due to noncompliance. Reward tags may be used to provide good estimates of noncompliance. Use of a reward tag program should be evaluated.

7. Tournament fishing did not appear to have a major negative impact on bass populations, though that potential does exist. Mortality of released fish may be a function of both water temperature and holding time in live wells. Tournaments during periods of very high water temperatures are a concern. Holding times could be reduced by shortening the fishing day or by providing more frequent weigh-ins.

8. Evaluation of the general status of bass populations can be accomplished with a minor expenditure of effort. Recommended procedures for evaluating other populations are in Appendix A.

TECHNIQUES USED

Creel Census

A stratified angler-count census was used to estimate angler effort. The census was initiated in late April and terminated in late October. The census was stratified by two-week intervals and by day type (weekday, weekend, and holiday). Within each interval, 10 weekdays (9 when a holiday occurred) and 4 weekend days (5 when a holiday occurred) were available for counting. Each day was partitioned into four equal count periods (early morning, late morning, afternoon, evening). A total of eight angler counts were made for each day type, with counting times selected so that two counts occurred in each of the four periods. Mean anglers/day for each interval was calculated as:

$$\overline{Y}_I = \frac{1}{N} \sum_{i=1}^{L} N_i \overline{Y}_i$$

Where N_i = the number of days per day type i (4 or 10).

$\overline{Y}_i$ = the mean number of anglers per day type i.

N = the total days in the interval (14).

the variance was estimated as:

$$\hat{V}(\overline{Y}_I) = \frac{1}{N^2} \sum_{i=1}^{L} N_i^2 \frac{s_y^2}{n_i}$$

when n_i = the number of counts made for day type i (8).

S_y = the standard deviation for y_i.

The total angler hours for each interval were estimated as:

$$T_I = \overline{Y}_I \cdot D_I$$

with variance:

$$V(T_I) = D_I^2 \cdot \hat{V}(\overline{Y}_I)$$

where D_I = the total daylight hours in the interval.

Total effort for the season (T_{st}) was estimated as the sum of the intervals.

Harvest rates and catch rates were estimated by interviewing as many angler parties as possible throughout each interval. The rates for each interval were calculated as:

$$\overline{C}_I = \frac{B}{W}$$

with variance:

$$\hat{V}(\overline{C}_I) = \frac{1}{N_I} \frac{\Sigma W_i (Ci-\overline{C}_I)^2}{\Sigma W_i - 1}$$

where B = total bass caught or harvested by interviewed anglers

W = total hours fished by interviewed anglers.

C_i = harvest or catch rate for interview i.

W_i = hours fished by anglers in interview i.

N_I = total numbers of parties interviewed in the interval.

Catch rates ($\overline{C}_{st}$) were estimated for the season by either a weighted mean through the intervals or by considering the entire season as one interval and calculating as above. The method used was selected on the basis of the best resulting precision for the total estimate. Total catch and harvest for the season were estimated as:

$$H_{st} = T_{st} \cdot \overline{C}_{st}$$

with a variance:

$$\hat{V}(H_{st}) = T_{st}^{2}\, \hat{V}\, (\overline{C}_{st}) + \overline{C}_{st}^{\;2}\; \hat{V}(T_{st})$$

Confidence intervals for the total harvest estimate were calculated as:

$$H_{st} \pm 2 \sqrt{\hat{V}(H_{st})}.$$

Estimates of angler pressure were made by dividing angler hours by the total surface area of each lake.

During the angler census, we made an effort to measure every bass checked in the creel. A composite length frequency of the catch and length-weight relationships already established (Rieman 1982) were used to estimate mean weight ($\overline{W}$) of bass in the catch. Yield was calculated as:

$$\frac{\overline{W} \cdot H_{st}}{\text{Surface Area}}$$

and

$$\overline{W} \cdot C_{st} \text{ (grams/angler hour).}$$

Angler opinions on restrictive regulations were noted by response to a question worded as follows:

> "Would you support more restrictive regulations for bass if they were necessary to maintain or enhance the numbers of large fish even though that meant you would have to release many or most of the bass you catch?"

Anglers were asked to pick one of the five possible responses:

Strongly support -- Support -- No Opinion -- Oppose -- Strongly Oppose

We categorized anglers by age group and by social group which included:

Family -- Family and Friends -- Friends -- Alone

We also noted whether anglers were members of a bass fishing organization or club.

Population Composition and Dynamics

Population sampling was conducted by electrofishing on five of the lateral lakes, Fernan Lake, and five other lakes located throughout the Idaho Panhandle. We used an 18-foot boat set up as a boom shocker. Power was supplied by a 2,200 watt generator and rectified to direct current using a Coffelt model VVP 2-C pulsator. The system was set up with 1/4 inch stainless steel cables as anodes suspended on two 10-foot booms off the bow and four cathodes trailing from each side of the boat. All sampling was done at night by fishing along the shoreline or offshore shoals. The collecting area was illuminated by flood lamps suspended above and below the water surface. A fishing crew consisted of two netters working on the bow and a driver. All bass collected were held in a recirculating live well until they could be examined. With each fish, we recorded total length, total weight, sex (if mature) and took a scale sample.

Length frequency data were recorded in 10 mm length groups. The proportional stock density index (PSD) (Anderson 1976) was used as a measure of stock structure. PSD was calculated using length frequency data from both electrofishing and catch samples as (number in sample $\geq$ 300 mm)/(number in sample $\geq$ 200 mm).

Aging was accomplished by scale analysis. Scales from all fish $\geq$ 200 mm were analyzed, but only a sample (at least ten) of the scales from each 10 mm length group less than 200 mm were read. Acetate impressions of each sample were projected on a scale projector. Annuli were marked and the distance of each annulus and the anterior radius from the focus was measured along the outermost radii. Length-at-age was back-calculated from scale measurements using a standard proportion method (Everhart et al. 1975). Mean length at age for each population was estimated from all samples. Differences in length-at-age between lakes and among year classes within a lake were analyzed using analysis-of-variance and Fisher's LSD test (Snedecor and Cochran, 1976).

Age composition of each population was estimated from age composition of each length group and the total length frequency. Total annual mortality was estimated by generating catch curves from age frequency and fitting the right limb through linear regression to estimate the slope (Ricker 1975).

Population estimates of bass were made on Thompson, Medicine, and Fernan lakes by electrofishing. We used mark-recapture methods of the Peterson type (Ricker 1975) on all three lakes in 1981. We used a Schnabel method (Ricker 1975) on Thompson Lake in 1982. All fish were marked with either an opercle punch or a dorsal fin punch. Each mark-or-recapture effort consisted of two or three full nights of electrofishing on each lake. Two weeks were allowed for redistribution of fish between mark-and-recapture efforts. Each population estimate was corrected to a spring, pre-fishery level by adding the estimated number of bass harvested prior to the first marking run to the population estimate.

Exploitation was estimated by comparing harvest and spring population estimates as:

$$E = \frac{H_{st}}{N}$$

Where: N = the spring population estimate.

With variance approximated as:

$$\hat{V}(E) = \frac{1}{N^2} \hat{V}(H_{st}) + \frac{H_{st}^2}{N^4} \hat{V}(N)$$

(Brian Dennis, Asst. Professor, University of Idaho College of Forestry personal communication.)

A confidence interval for the exploitation estimate was calculated as:

$$E \pm 2 \quad V(E)$$

Exploitation was estimated for specific size groups ($\geq$200 mm, $\geq$250 mm, $\geq$300 mm) by adjusting both harvest and population estimates with the appropriate length frequency. The composite catch length frequencies were adjusted to a spring length frequency to compensate for growth.

Exploitation was also estimated on the basis of angler tag returns. During electrofishing, all fish 250 mm (200 mm in Fernan) were tagged with numbered Floy tags. To encourage tag returns, we posted all fishing access sites and provided convenient "drop" locations close to the lakes. Tag exploitation estimates were corrected for harvest occurring prior to tagging using a simple proportion. Non-compliance for tag returns was calculated by comparing estimates of exploitation from tagging data and from harvest-population data.

Population Model

An equilibrium yield model of the dynamic pool type (Ricker 1975) was made available on a Fortran computer program (Paulik and Bayliff 1976). We obtained a modified version of this program (Latta 1975) through the University of Michigan and adapted it to the University of Idaho IBM system. The model was used to predict yield per recruit at varying levels of fishing mortality and age at entry to the fishery. Output data on biomass at age was used to calculate relative abundance of fish at age and size, and PSD for varying levels of fishing mortality and age of entry to the fishery. Input data for each lake consisted of weight-at-age, base fishing mortality, natural mortality, weight at recruitment, number at recruitment, time or age of entry to the fishery, and time periods for calculation. For time periods, the year was broken into two three-month periods for the growing season and a six-month period for the remaining season. Weight-at-age was estimated based on length-at-age and length-weight data. Growth was assumed to occur only during the two quarters of the growing season. Fishing mortality was set at a base level of 0.1, but multipliers were used to provide mortalities equivalent to a range of exploitation from 0.1 to 0.9.

Fishing was assumed to occur only during the growing season. Natural mortality was held constant and assumed to occur throughout the year. Age at recruitment was assumed to be four years in all lakes and weight was appropriately estimated. Number at recruitment was held constant and arbitrarily set at 1,000. Age at entry to the fishery was varied to simulate the effects of no regulation and 305 mm (12"), 356 mm (14"), and 406 mm (16") size limits.

Tournaments

Two major tournaments were held on the Coeur d'Alene Lake system during both 1981 and 1982. At each tournament we collected all bass from the participants at the daily weigh-in. We marked each fish with a fin or opercle punch, coded by lake of origin and placed the fish in a live pen. Following the weigh-in we measured all fish, and noted mortality and condition. All fish which appeared to be in good condition were tagged. In 1981 all tagged fish were released at the weigh-in site. Dispersal of bass from the release point was evaluated on the basis of tag returns. In 1982 all bass were transported back to a single study lake. The transplants were made in an effort to evaluate the potential for population manipulation and control of forage populations.

FINDINGS

Creel Census

Effort and Pressure

Total estimated angler hours on the study lakes ranged from 1,900 on Swan in 1982 to 55,400 on Fernan the same year (Table 2). On Thompson, Anderson, and Swan lakes bass anglers contributed over half of the total effort (50-79%), but less than that on Medicine (28%). Bass anglers contributed only 8% to 13% of the total fishing effort on Fernan Lake. Even so, bass fishing effort on Fernan was significantly greater than on the other study lakes (Table 2). Fishing effort did not vary significantly between the two years on any of the lateral lakes, but did increase significantly on Fernan in 1982.

Fishing pressure ranged from 6.4 hours/ha on Swan Lake in 1982 to 382 hours/ha on Fernan the same year. Fishing pressure by bass anglers ranged from 5.1 hours/ha on Swan to 43.4 hours/ha on Fernan (Table 2).

Total angling effort on Fernan and Medicine lakes was very high during spring and early summer, tapering off during mid-summer and early fall (Fig. 2). Angling effort on the lakes where bass fishing was more important was more stable throughout the season. However, a trend of declining effort was still evident on the more-heavily fished lakes such as Thompson and Anderson.

Harvest and Catch Rates

Total harvest rates for bass were relatively consistent among Thompson, Anderson, and Swan lakes (0.10-0.16 bass/hour), but was lower on Blue, Medicine, and Fernan (Table 3). Harvest rate for bass anglers was typically higher and more consistent among all the lakes. Bass angler harvest rate was highest on Fernan (0.26/hour), but still low on Blue (0.06/hour). Harvest rates were relatively consistent between years.

Table 2 . Estimated angler effort and pressure for six lakes in north Idaho during 1981 and 1982. The associated 95% error bounds (E.B.) are also shown.

Lake	Thompson		Anderson		Swan		Medicine		Blue		Fernan	
Year	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82
Total angler hours	4,800	4,900	3,900	4,200	2,300	1,900	10,300	--	--	2,100	46,800	55,400
(±E.B.)	(675)	(700)	(712)	(1,300)	(400)	(450)	(1,200)	--	--	(520)	(4,620)	(5,600)
Bass angler hours	3,100	2,800	2,700	2,100	1,700	1,500	2,900	--	--	1,600	6,300	4,700
(±E.B.)	(490)	(550)	(640)	(520)	(330)	(421)	(540)	--	--	(412)	(900)	(830)
Total pressure (hrs/ha)	23.8	24.3	19.0	20.5	7.8	6.4	108.0	--	--	15.4	322.7	382.0
Bass angler pressure (hrs/ha)	15.4	13.9	13.1	10.2	5.7	5.1	30.5	--	--	11.8	43.4	32.4

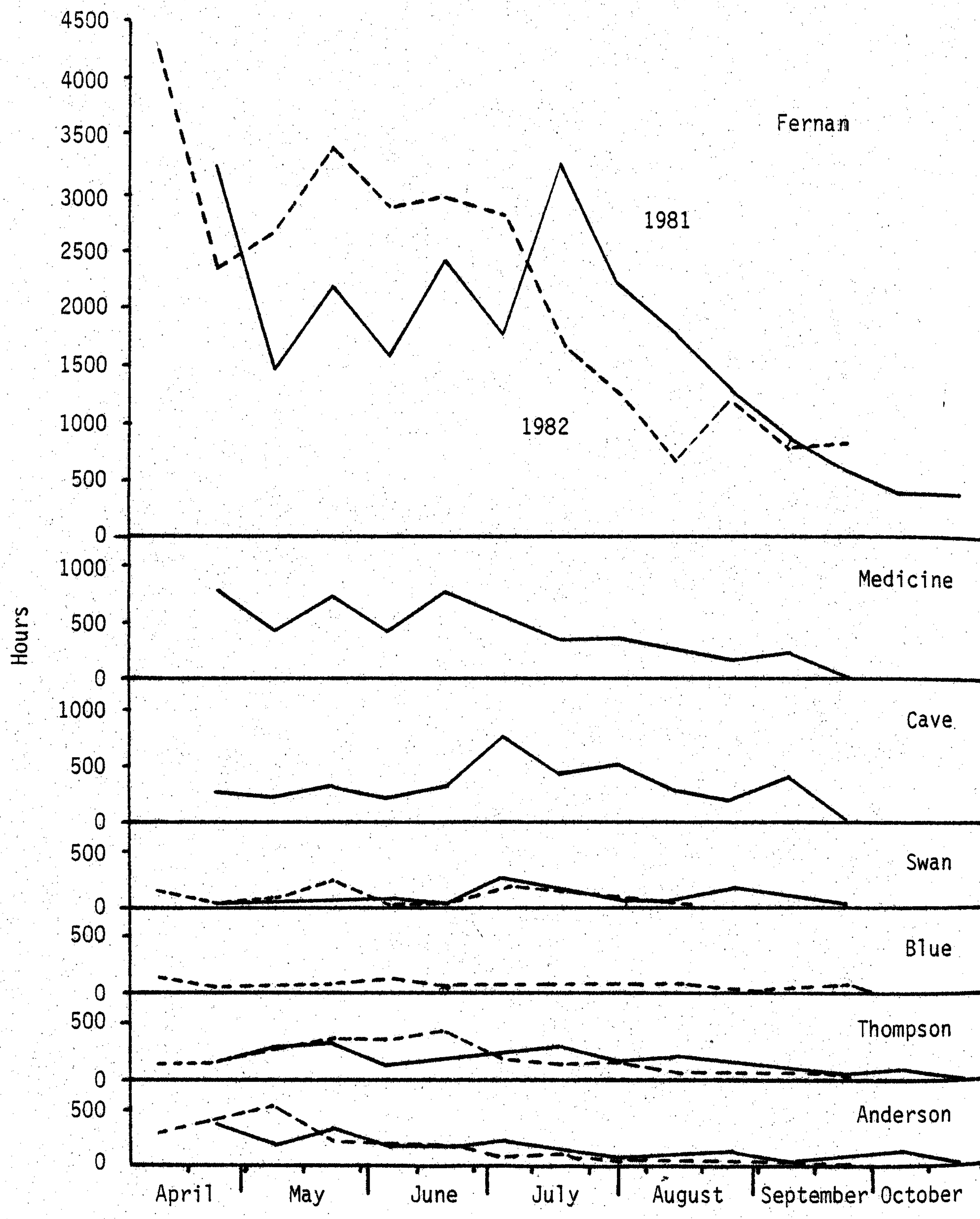

Figure 2. Estimated effort (hours) expended by anglers by two-week interval on seven lakes in northern Idaho during 1981 and 1982.

Table 3. Estimated harvest rates and catch rates for bass for six lakes in north Idaho during 1981 and 1982.

	Thompson		Anderson		Swan		Medicine		Blue		Fernan	
	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82
Total harvest	0.15	0.16	0.13	0.10	0.14	0.13	0.04	--	--	0.05	0.07	0.06
Bass angler harvest/hr	0.22	0.17	0.16	0.14	0.15	0.14	0.11	--	--	0.06	0.21	0.26
Total catch/hr	0.34	0.23	0.21	0.19	0.22	0.15	0.14	--	--	0.13	0.16	0.12
Bass Angler catch/hr	0.50	0.26	0.27	0.21	0.25	0.16	0.34	--	--	0.13	0.58	0.53
Bass Angler harvest/hr for bass $\geq$ 300	0.20	0.14	0.15	0.12	0.14	0.12	0.09	--	--	0.06	0.02	0.02
Bass angler yield (grams/hr)	147	121	97	95	108	92	86	--	--	51	42	31

Bass catch rates, both total and bass-angler-only, were typically much greater (often two-to three-fold) than harvest rates (Table 3). Bass angler catch rates ranged from 0.13/hour on Blue Lake to 0.58/hour on Fernan.

Harvest rate of bass 300 mm was relatively high on Thompson, Anderson, and Swan lakes (0.12-0.20/hour), lower on Medicine (0.09) and Blue (0.06), and quite low on Fernan (0.02). Estimated yield to bass anglers (grams/hour) followed a similar trend (Table 3).

Harvest, Catch, and Yield

Estimated harvest of bass ranged from 117 on Blue Lake in 1982 to 3,314 on Fernan in 1981 (Table 4). Estimated harvest did not differ significantly between years on individual lakes.

The catch of bass exceeded the harvest of bass on all lakes (Table 4). The differences varied among lakes and years, but total catch averaged two times the harvest for all lakes and years combined. Estimated yield of bass ranged from 99 kg on Blue Lake to 656 kg on Fernan in 1981. Yield/surface area ranged from 0.6 kg/ha on Swan Lake in 1982 to 4.5 kg/ha on Fernan in 1981. Yield did not vary significantly between years on the lateral lakes, but did decline on Fernan in 1982.

Harvest of Other Species

In addition to largemouth bass, northern pike, black crappie, yellow perch, brown bullhead, pumpkinseed, rainbow trout, and cutthroat trout were checked in the creel. The total estimated harvest of all species was relatively low on Thompson, Anderson, and Swan with the exception of crappie and bullhead on Anderson Lake during 1982 (Table 5). Crappie and bullhead harvest was relatively important on Medicine Lake, and all species with the exception of pike and bullhead were taken in relatively high numbers on Fernan Lake.

Table 4. Estimated harvest, catch yield and yield/surface area of bass for six lakes in north Idaho during 1981 and 1982. The associated 95% error bounds (E.B.) are also shown for harvest.

	Thompson		Anderson		Swan		Medicine		Blue		Fernan	
	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82
Harvest (No.)	746	792	511	401	314	256	434	--	--	117	3,314	3,305
(±E.B.)	(340)	(342)	(250)	(341)	(123)	(145)	(274)	--	--	(101)	(761)	(955)
Catch	1,675	1,146	836	802	510	282	1,463	--	--	282	7,497	6,733
Yield (kg)	498	565	310	271	227	168	341	--	--	99	656	396
Yield (kg/ha)	2.5	2.8	1.5	1.3	0.8	0.6	3.6	--	--	0.7	4.5	2.7

Table 5. Estimated harvest of six types of fish from six lakes in north Idaho during 1981 and 1982.

Lake	Thompson		Anderson		Swan		Medicine		Blue		Fernan	
Year	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82	'81	'82
Northern Pike	20	43	0	0	95	151	87	--	--	39	0	0
Crappie	194	375	464	2,005	107	0	1,538	--	--	39	6,470	2,780
Perch	326	343	12	150	95	125	471	--	--	110	11,005	8,995
Bullhead	531	225	337	2,757	124	0	3,187	--	--	0	120	276
Sunfish	255	0	186	301	0	7	595	--	--	0	6,970	1,934
Trout	0	0	12	0	6	0	0	--	--	8	7,209	14,123

Angler Composition and Opinion

The age composition of anglers was similar between the lateral lakes and Fernan Lake, with the majority of anglers falling in our mid-age class of 15-60 years (Table 6). Fernan Lake did have a significantly greater proportion of anglers in the youngest age group. The proportion of family groups fishing Fernan and the lateral lakes was similar. There was a significantly greater proportion of anglers fishing alone on Fernan. The proportion of anglers that were also "organized" bass fishermen was much greater on the lateral lakes than on Fernan Lake.

On both the lateral lakes and Fernan Lake, a major portion (71-75%) of all anglers said they would support or strongly support more restrictive bass regulations (Table 7). A relatively small part (1-3%) of the respondents said they would strongly oppose such regulation.

Population Composition and Dynamics

Lengths

We collected a total of 1,859 bass through electrofishing on Fernan Lake during 1981 and 1982. Fish in the sample ranged from 50 mm to 540 mm in length, with a major mode in the distribution around 200 mm during both years (Fig. 3). Few bass in those samples exceeded 300 mm. The PSD of bass $\geq$ 300 mm calculated for Fernan from electrofishing data was 0.11 in 1981 and 0.08 in 1982. Our total sample for Thompson Lake was 1,210 bass during 1981 and 1982. Lengths in the sample ranged from 40 mm to 550 mm, with modes around 150 mm and 300 to 340 mm. The calculated PSD's in Thompson were 0.61 and 0.60 for 1981 and 1982, respectively.

Only one year of electrofishing data was collected on Medicine and Anderson lakes. We collected 433 bass on Medicine Lake in 1981. Fish ranged from 50 to 540 mm in length. We calculated a PSD of 0.44 from that sample. We sampled 103 bass on Anderson Lake ranging from 100 mm to 510 mm in length. We calculated a PSD of 0.93 from that 1981 sample.

We electrofished Blue Lake and Swan Lake both years, but had very poor success collecting bass. In seven nights of electrofishing in 1981 and 1982, we sampled only 32 bass from both lakes.

Table 6. Age and social group of anglers on the Coeur d'Alene lateral lakes and Fernan Lake in north Idaho during 1982.

AGE GROUP	(N)	≤15 yr.	15-60 yr.	≥60 yr.
Lateral lakes	(454)	10%	80%	10%
Fernan Lake	(1,311)	19%	73%	8%

SOCIAL GROUP	(N)	Family	Family & friends	Friends	Alone	Organized bass fishermen (% of total)
Lateral lakes	(210)	33%	18%	30%	19%	25%
Fernan Lake	(735)	39%	5%	14%	42%	0.4%

Table 7. Angler opinion regarding more restrictive regulation for bass fishing on the Coeur d'Alene lateral lakes and Fernan Lake during 1982.

	(N)	Strongly support	Support	No opinion	Oppose	Strongly oppose
Lateral lakes	(203)	36%	39%)	15%	7%	3%
Fernan Lake	(359)	18%	53%	20%	8%	1%

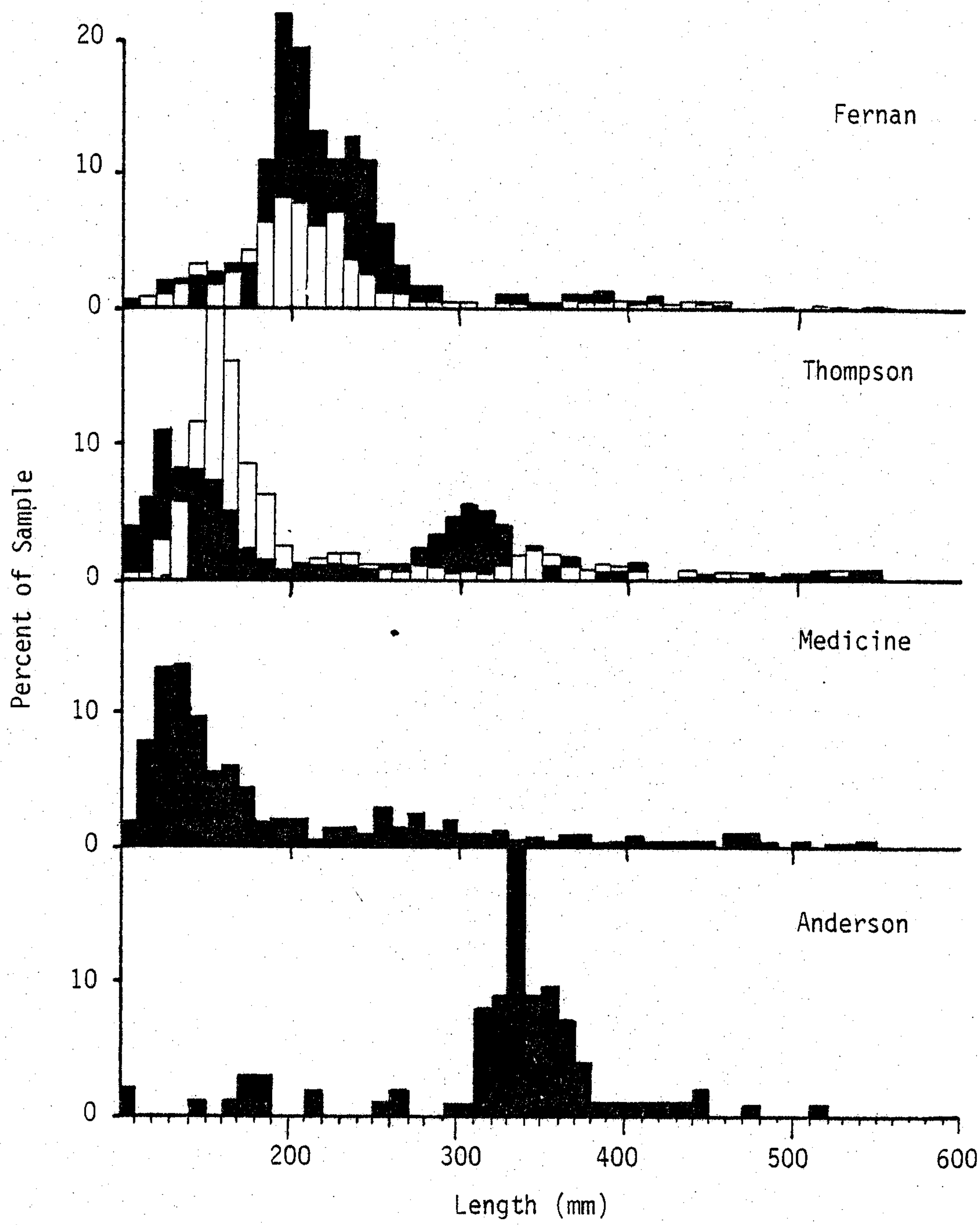

Figure 3. Length frequency of bass from electrofishing samples in four north Idaho lakes during 1981 (dark outline) and 1982 (light outline).

During 1982, we did some limited electrofishing on five other lakes located in north Idaho. Numbers of bass collected in one night of fishing on each lake ranged from 205 on Robinson to 32 on Benewah. We found bass ranging from 100 mm to approximately 500 mm on all lakes, but the relative numbers of large fish varied (Fig. 4). The Hayden Lake and Robinson Lake samples had few fish exceeding 300 mm. Both Round Lake and Benewah Lake had relatively large numbers of bass between 300 mm and 500 mm. PSD's calculated for these lakes ranged from 0.06 on Robinson to 0.52 on Benewah (Table 8).

The length frequencies of bass in the catch were similar among Thompson, Blue, Swan, Medicine, and Anderson lakes. Most bass taken in those fisheries ranged from 300 to 500 mm (Fig. 5). Bass taken by anglers on Fernan Lake were considerably smaller, with most fish ranging from 200 to 300 mm in length. PSD's calculated from catch-length frequencies ranged from 0.84 to 1.00 on the lateral lakes, but only 0.10 to 0.12 on Fernan (Table 8).

Age and Mortality

Each of the populations sampled showed typical age distributions, with most fish in the samples concentrated in the younger age groups (Table 9). The 1977 year class (age 4 in 1981) appeared to be a relatively strong cohort in Fernan and Thompson lakes. It appeared that bass were generally fully recruited to the electrofishing gear by age 3 or 4 and to the catch by age 4. Fish ranging to age 14 were sampled in Fernan and Thompson lakes and to age 11 in Medicine and Swan. Catch curves generated from both electrofishing and catch data were used to estimate total mortality. Curves estimated from electrofishing data tended to be concave in shape for both Fernan and Medicine lakes (Fig. 6), but not obviously so for Thompson Lake. A concave shape suggests that mortality may have been increasing through time and may be accurate only for a short period following recruitment. For that reason, estimates of mortality were made for the age 4-9 period and the age 4-6 period. With the electrofishing data, estimated mortality increased with the shorter period confirming the concave appearance. Estimates of mortality from catch data tended to be lower than estimates from electrofishing data. Maximum estimates of total annual mortality (A) ranged from 0.32 on Swan Lake to 0.79 on Fernan Lake (Table 10).

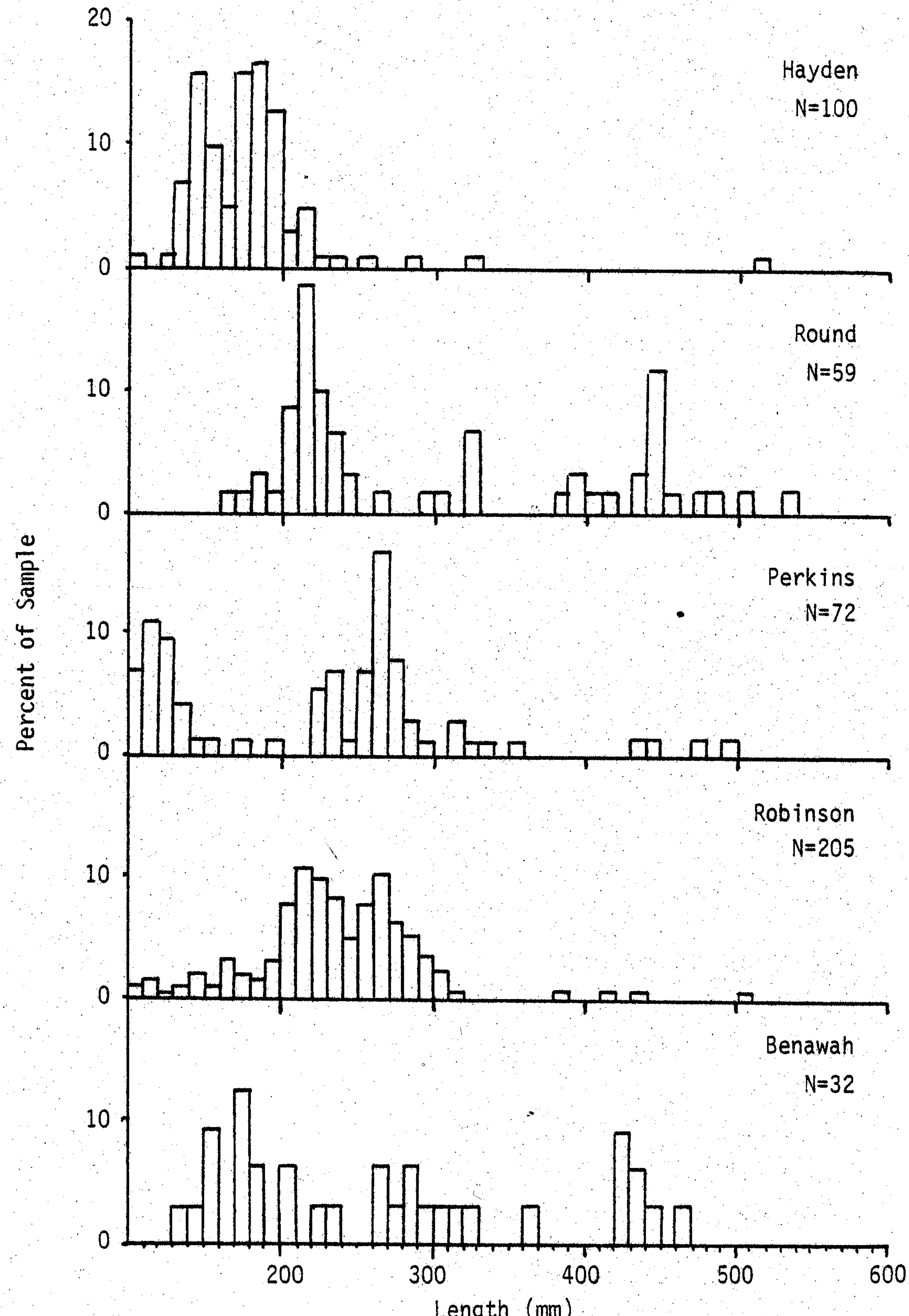

Figure 4. Length frequency of bass from electrofishing samples in five north Idaho lakes during 1982.

Table 8. Proportional stock density index (PSD) calculated from electrofishing samples and angler creel samples for 11 lakes in north Idaho during 1981 and 1982. The sample size (N) is also shown.

	Electrofishing				Creel			
Lake	1981	(N)	1982	(N)	1981	(N)	1982	(N)
Thompson	.61	(232)	.60	(169)	.93	(111)	.84	(63)
Anderson	.93	(92)	--		1.00	(97)	.88	(77)
Swan	--		--		.91	(119)	.87	(71)
Medicine	.44	(127)	--		.90	(62)	--	
Blue	--		--		--		.94	(46)
Fernan	.11	(555)	.08	(531)	.10	(248)	.12	(102)
Robinson	--		.06	(163)	--		--	
Perkins	--		.20	(45)	--		--	
Round (State Park)	--		.44	(54)	--		--	
Benewah	--		.52	(21)	--		--	
Hayden	--		.14	(14)	--		--	

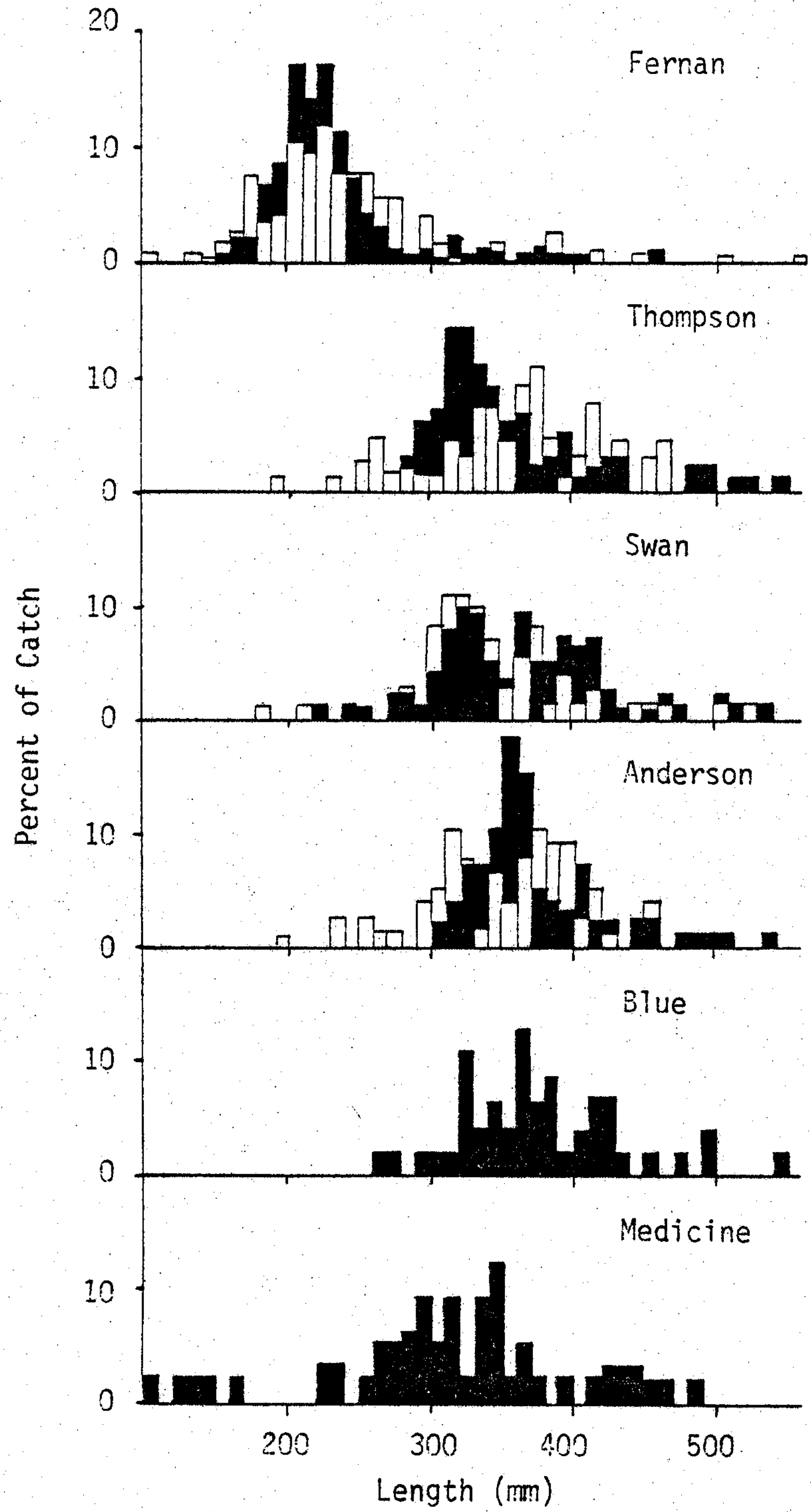

Figure 5. Length frequency of bass in the catch from six north Idaho lakes during 1981 (dark) and 1982 (light).

Table 9. Estimated age composition (numbers) of largemouth bass collected by electrofishing and from the angler creel on eight north Idaho lakes.

LAKE	(N)	Age 2	3	4	5	6	7	8	9	10	11	12	13	14
FERNAN														
1981 Electrofish	(1,064)	76	137	779	12	28	11	10	5	1	3	2		
1982 Electrofish	(778)	65	222	73	377	9	7	6	7	6	2	2	1	1
1981 Catch	(316)	9	42	239	8	12	3	3	1	0	1			
1982 Catch	(124)	9	37	13	53	3	4	2	2	0	1			
THOMPSON														
1981 Electrofish	(499)	250	36	142	33	20	7	2	3	1	3	2		
1982 Electrofish	(699)	49	501	36	52	15	20	7	1	5	1	1	1	1
1981 Catch	(110)			67	15	16	5	3	2	1	1			
1982 Catch	(63)		6	12	18	11	10	3	1	2				
MEDICINE														
1981 Electrofish	(429)	299	12	74	17	9	6	7	2	1	1			
1981 Catch	(67)	5	3	26	18	3	4	4	4					
SWAN														
1981 Catch	(117)	6	47	18	27	12	4	3	2	0	1			
1982 Catch	(77)	4	30	11	21	6	4	0	1					
BLUE														
1981 Catch	(52)		6	16	16	3	3	2	4	0	1	0	1	
PERKINS														
1981 Electrofish	(69)	23	2	10	22	4	2	3	3					
ROBINSON														
1982 Electrofish	(206)	14	22	84	56	22	5	0	2					
ROUND														
1982 Electrofish	(59)	2	33	0	5	1	4	6	2	2	2	1		

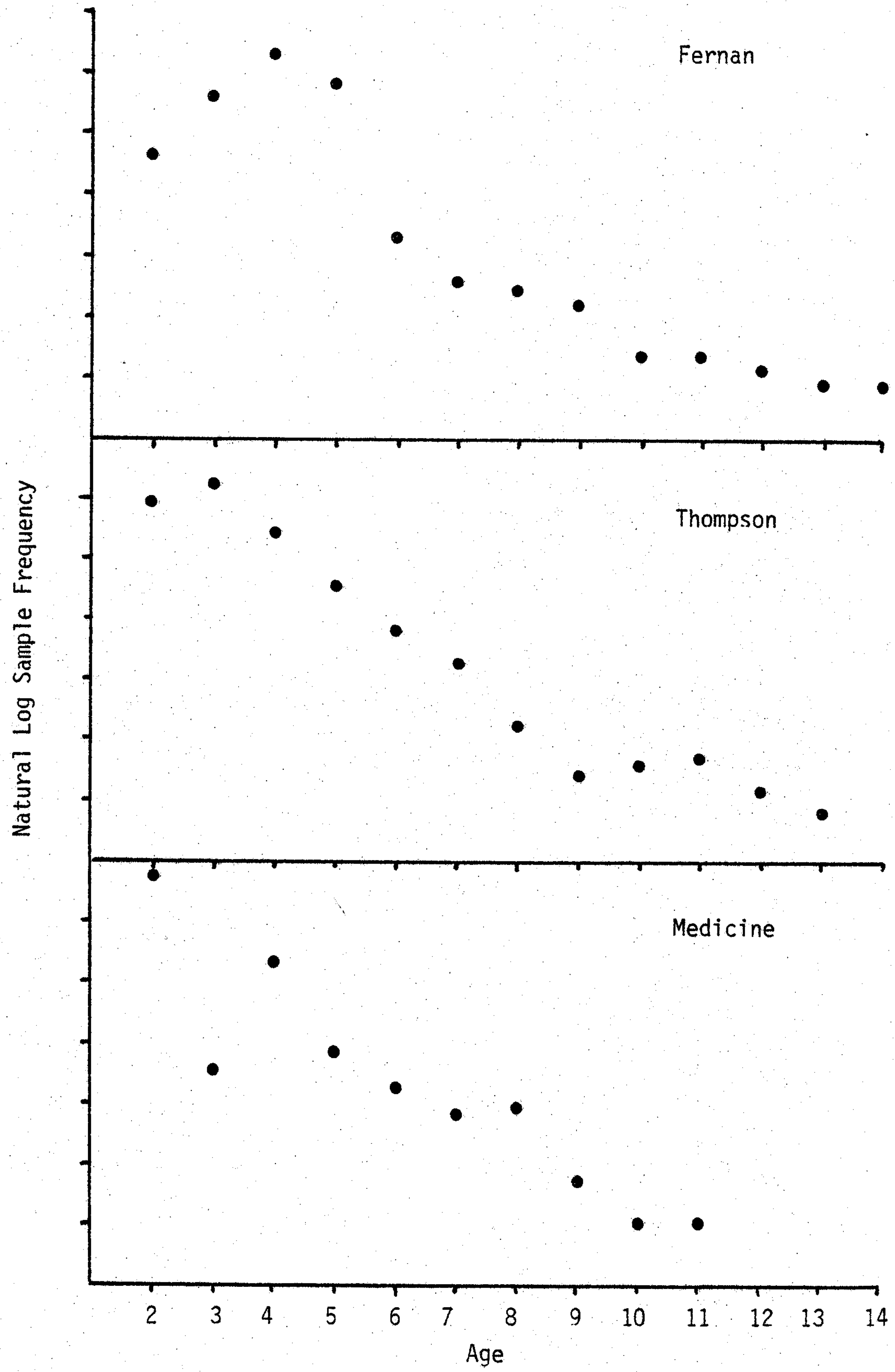

Figure 6. Catch curves generated from age composition of electrofishi samples on three north Idaho lakes.

Table 10. Total instantaneous (Z) and total annual (A) mortality estimated from catch curves for bass populations in eight north Idaho lakes.

Lake	Electrofishing samples				Catch samples			
	AGE 4-9		AGE 4-6		AGE 4-9		AGE 4-6	
	Z	A	Z	A	Z	A	Z	A
FERNAN 1981+1982	0.89	0.59	1.54	0.79	0.82	0.56	1.31	0.73
THOMPSON 1981+1982	0.75	0.53	0.84	0.57	0.62	0.46	0.45	0.36
MEDICINE 1981	0.60	0.45	1.05	0.65	0.39	0.32	1.05	0.65
SWAN 1981+1982	--	--	--	--	0.59	0.44	0.39	0.32
BLUE 1982	--	--	--	--	0.38	0.31	0.84	0.57

Growth

Length at age was back-calculated from scale data collected from three lakes in 1981 and six lakes in 1982 (Appendix B). Apparent growth rate differed among the lakes as depicted by estimated length at age (Fig. 7) (Table 11). Medicine, Swan, and Blue lakes tended to have the highest growth rate, with maximum differences in length-at-age occurring at intermediate ages. Thompson Lake bass had intermediate growth, while fish in Fernan and Round lakes had the lowest growth rates. Length-at-age tended to converge among the lakes at older ages.

Analysis of variance of length-at-age among lakes (Round Lake excluded) through age 6 (sample sizes were too low for statistical analysis after age 6) indicated significant differences for every age group (Appendix C). There was a consistent trend of length-at-age on Fernan being significantly lower than the other lakes.

Within-lake comparisons of length-at-age among year classes also produced significant differences. However, the differences between age classes was inconsistent from 1981 to 1982. The data suggest that there may be some variation in the scale reading method that can confound comparison of length-at-age among year classes within a single lake.

Growth estimated for the Idaho lakes is similar to an average reported for Wisconsin lakes located at similar latitude, but considerably lower than that reported for more southerly Oklahoma lakes (Fig 8).

Population Estimates

Total spring population estimates ranged from 2,206 bass in Medicine Lake in 1981 to 4,985 bass in Fernan Lake during the same year (Table 12). Total density of bass ranged from 16.0 fish/ on Thompson in 1981 to 34.4 fish/ha on Fernan in 1981. Density of bass $\geq$300 mm was reversed, with only 2.2/ha on Fernan in 1981 and 5.5 on Thompson in the same year. Standing crop was similar on each lake in 1981 (5.8-6.0 kg/ha), but lower on Thompson Lake during 1982 (Table 12).

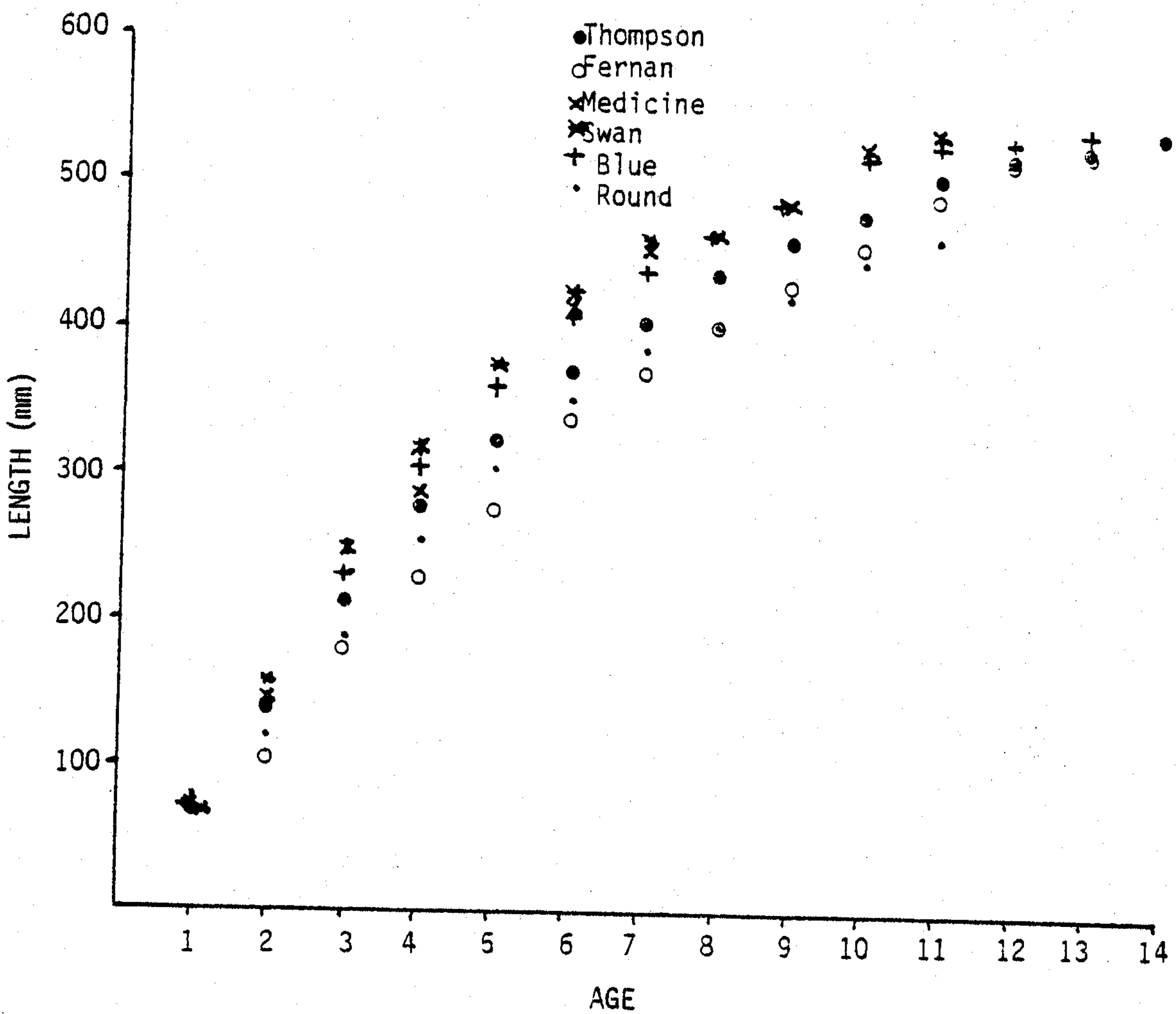

Figure 7. Back calculated length-at-age for bass sampled from six lakes in north Idaho during 1981 and 1982.

Table 11. Estimated mean[a] length at age (mm) for bass collected from six north Idaho lakes during 1981 and 1982.

Lake	Age 1	2	3	4	5	6	7	8	9	10	11	12		13
Fernan 1981+1982	63	101	182	230	276	341	374	404	432	460	496	519	531	545
Thompson 1981+1982	69	139	212	277	325	372	408	440	466	482	509	525	530	540
Medicine	71	148	220	290	377	417	457	464	496	529	540			
Blue	72	150	231	304	363	411	441	469	491	523	535	530	540	
Swan	70	159	248	318	373	424	466	458	467	462	471	489	506	520
Round	61	123	189	256	307	354	387	403	423	447	466	462	467	

[a] Means are weighted based on the sample size in each year class.

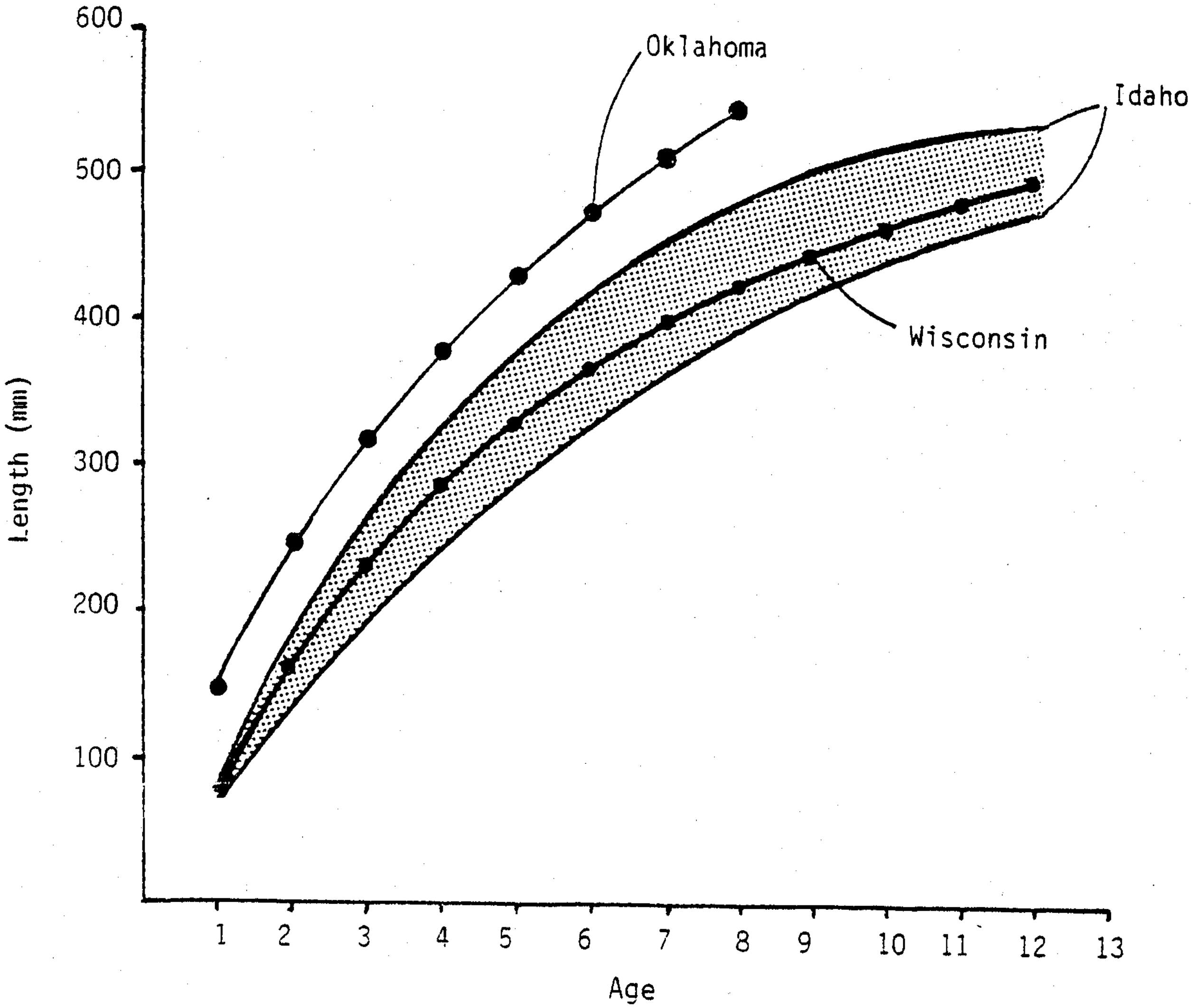

Figure 8. Length-at-age for bass from north Idaho lakes and populations in Oklahoma and Wisconsin (from Anderson 1975).

Table 12. Spring bass population estimates and 95% error bounds (E.B.) for three lakes in north Idaho during 1981 and 1982.

	Fernan		Thompson		Medicine
	1981	1982	1981	1982	1981
Total Spring Population	4,985	4,080	3,739	4,190	2,206
E.B.	±17%	±26%	±75%	±28%	±38%
Population ≥ 200 mm	2,781	2,299	--	--	--
E.B.	±19%	±27%	--	--	--
Population ≥ 250 mm	514	885	1,646	1,058	581
E.B.	±40%	±34%	±56%	±29%	±39%
Population ≥ 300 mm	373	304	1,111	862	368
E.B.	--	--	--	--	--
Total bass/ha	34.4	28.1	16.0	20.8	23.22
Bass ≥ 300 mm/ha	2.6	2.2	5.5	4.3	3.9
Total kg/ha	5.9	5.8	5.9	3.9	6.0

Exploitation

Exploitation estimated from population and harvest data for bass of a size fully recruited to the fishery ranged from a mean of 0.74 to 0.78 on Fernan to 0.57 on Thompson Lake (Table 13). Estimated exploitation was higher on both Thompson and Fernan in 1982 than during 1981. The precision of the exploitation estimates was relatively poor, however, and differences were not found to be significant.

Exploitation estimated from tag returns showed the same trends as the harvest population data, with Fernan showing the highest exploitation, Medicine intermediate, and Thompson the lowest (Table 13). The tag data, however, did not indicate dramatic differences between years. Exploitation estimated from tag returns was considerably lower than that from the harvest-population method. The difference may be considered a result of the bias due to angler noncompliance in tag returns. Noncompliance calcuated by comparing the estimates from both methods ranged from 0.58 to 0.73, with a mean of 0.67 (Table 14).

With limited data, there appeared to be a positive relationship between exploitation and total annual morality (Fig. 9). A negative relationship was observed between exploitation and PSD (Fig. 10).

Natural Mortality

Natural mortality estimated from fishing mortality and from total mortality appeared to be quite low for all three lakes where complete data was available. Even using the maximum estimated total mortality, fishing mortality and exploitation were equal to or only slightly less than total mortality (Table 15). The resultant estimates of instantaneous natural mortality (M) ranged from 0.00 to 0.09.

Natural mortality was also examined by plotting total mortality (Z) against fishing effort (Fig. 11). If a normal, straight line is used to fit the data, the estimate of natural mortality (the intercept) approximates 0.2. The data might also be interpreted to show a curvilinear fit, suggesting that natural mortality may be higher (0.2 to 0.5) with no fishing pressure, than with moderate-to-high fishing pressure.

Table 13. Exploitation of bass estimated from population and harvest data for three lakes in north Idaho during 1981 and 1982. Available 95% error bounds are shown in ( ).

	Exploitation of bass		
	≥ 200 mm	≥ 250 mm	≥ 300 mm
Fernan 1981	0.68 (±30%)	0.63 (±41%)	0.63
1982	0.80 (±39%)	0.93 (±53%)	0.95
$\bar{x}$	0.74	0.78	0.79
Thompson 1981	--	0.45 (±55%)	0.51
1982	--	0.69 (±52%)	0.64
$\bar{x}$		0.57	0.57
Medicine 1981	--	0.66 (±73%)	.93

Table 14. Exploitation of bass[a] estimated from tag returns and non-compliance[b] of tag returns estimated by comparison of tag and population-harvest data.

	Exploitation	Non-compliance
Fernan 1981	0.29	0.58
1982	0.27	0.73
Thompson 1981	0.17	0.63
1982	0.18	0.73
Medicine 1981	0.21	0.68
	$\bar{x}$	0.67

[a]The estimate is for bass ≥ 200 mm in Fernan and bass ≥ 250 mm in Thompson and Medicine.

[b]Non-compliance is the proportion of recaptured tags not reported by anglers.

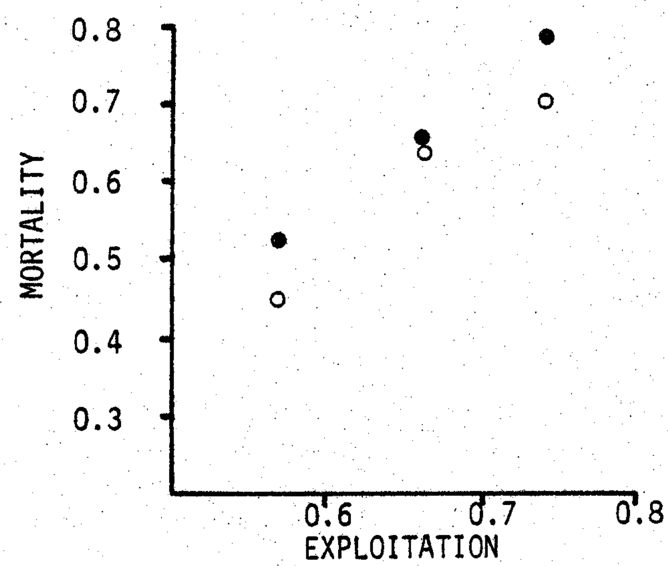

Figure 9. Relationship of exploitation and total annual mortality for bass in three lakes in north Idaho. Open points represent catch data closed points represent electrofishing data.

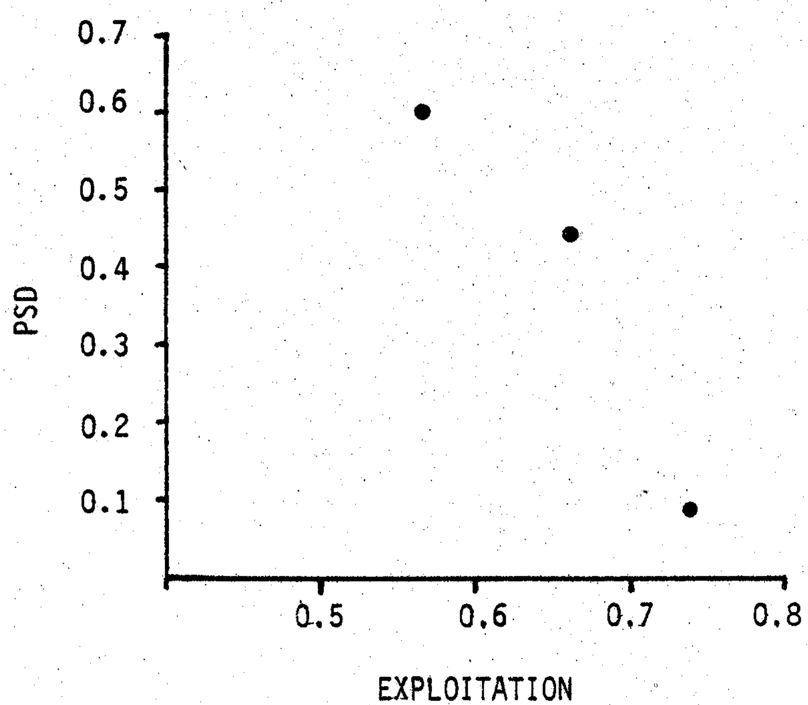

Figure 10. Relationship of exploitation and PSD for bass in three lakes in north Idaho.

Table 15. Estimated[a] natural mortality (M) and fishing mortality (F) using maximum estimates of total annual (A) and instantaneous (Z) mortality and exploitation estimated for fish fully recruited to the fishery.

LAKE	E	F	Z	A	M
Fernan	0.74	1.46	1.54	0.78	0.09
Thompson	0.57	0.84	0.84	0.57	0.00
Medicine	0.66	1.05	1.05	0.65	0.00

[a]Natural mortality is computed from Z-F=M where $\frac{EZ}{A} = F$ (Ricker 1975).

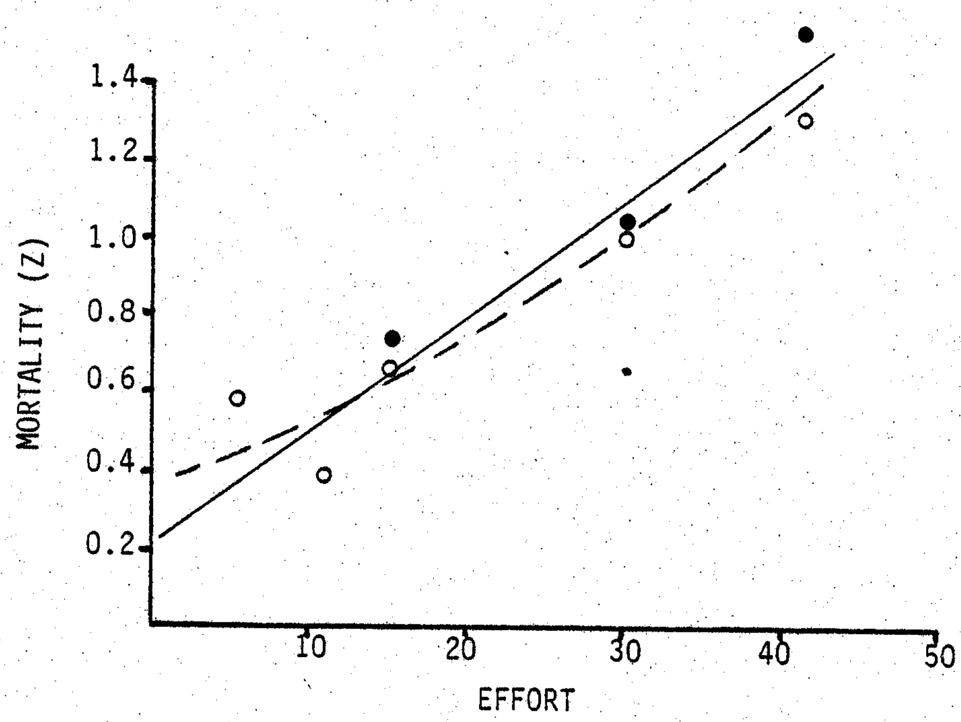

Figure 11. Relationship of fishing effort (hours/ha) and total instantaneous mortality (Z) of bass in five lakes in north Idaho. The regression lines are fitted by inspection. Open points represent catch data, closed points represent electrofishing data.

Population Models

The dynamic pool model was run using growth data from Fernan, Thompson, and Medicine lakes. Natural mortality (M) was set at 0.1. Exploitation was varied over the range of 0.1 to 0.9 and age-at-entry to the fishery was varied to approximately a 305 mm (12") size limit on Fernan and 305 mm, 356 mm (14"), and 406 mm (16") size limits on Thompson and Medicine.

Yield per Recruit

Predicted yield per recruit showed relationships similar to exploitation for each lake when no size limit was used. Yield was at a maximum, with a relatively low expllitation (0.2 to 0.3) and declined at higher rates (Fig. 12). Maximum yield was approximately 450 g/recruit for Fernan Lake, 600 g in Thompson, and 800 g in Medicine. At the level of current exploitation use of a 305 mm minimum size limit produced a dramatic increase (approximately 100%) in yield for Fernan Lake and a moderate increase (20-30%) in yield for Medicine and Thompson lakes. The 356 mm and 406 mm limits resulted in a further increase in yield

PSD

A relationship of predicted PSD ($\geq$300 mm) and exploitation was plotted for each lake. At current exploitation, the model predicts a PSD of 0.0 for Fernan, 0.3 for Medicine Lake, and 0.4 for Thompson Lake (Fig. 13). An arbitrary PSD of 0.4 was predicted to occur at exploitation rates of 0.33 in Fernan, 0.48 in Thompson, and 0.54 in Medicine. Size limits provided some increase in PSD at a given exploitation and an increase in the level of exploitation that resulted in a PSD of 0.4.

Population Structure

From 1982 data, the bass population in Fernan Lake had relatively large numbers of fish from 200 to 300 mm, but very few fish exceeding 350 mm. Under the current exploitation (1982-1981 $\bar{x}$), the model results indicate that the numbers of 200 to 300 mm bass will decline (Fig. 14). An increase in exploitation to 0.84 resulted in even fewer large fish. Application of a 305 mm size limit resulted in a dramatic increase in numbers of fish from 275 to 375 mm.

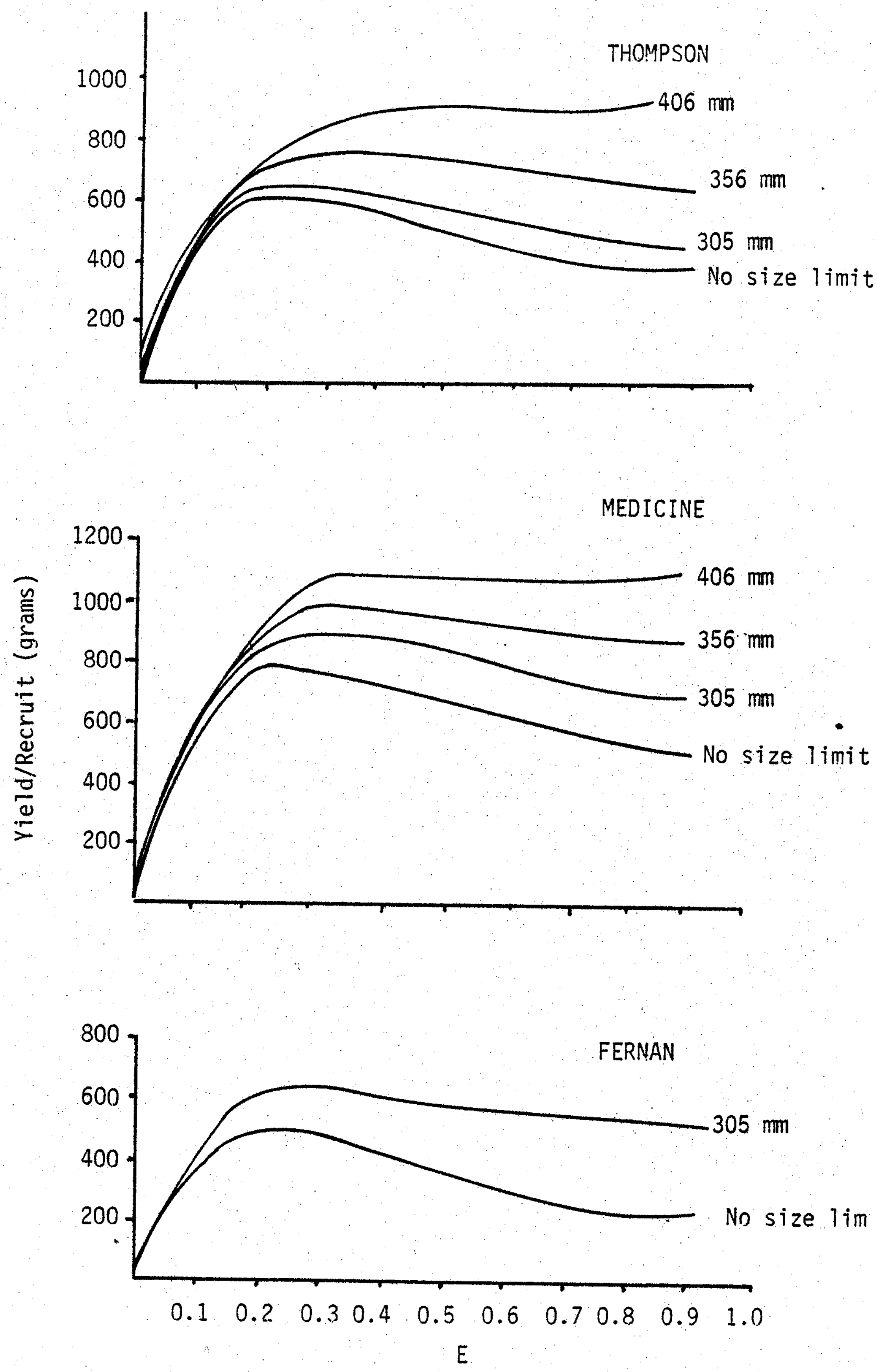

Figure 12. Yield per recruit (grams) with varying levels of exploitation (E) and size limits predicted from the Ricker equilibrium yield model for bass in three lakes in north I

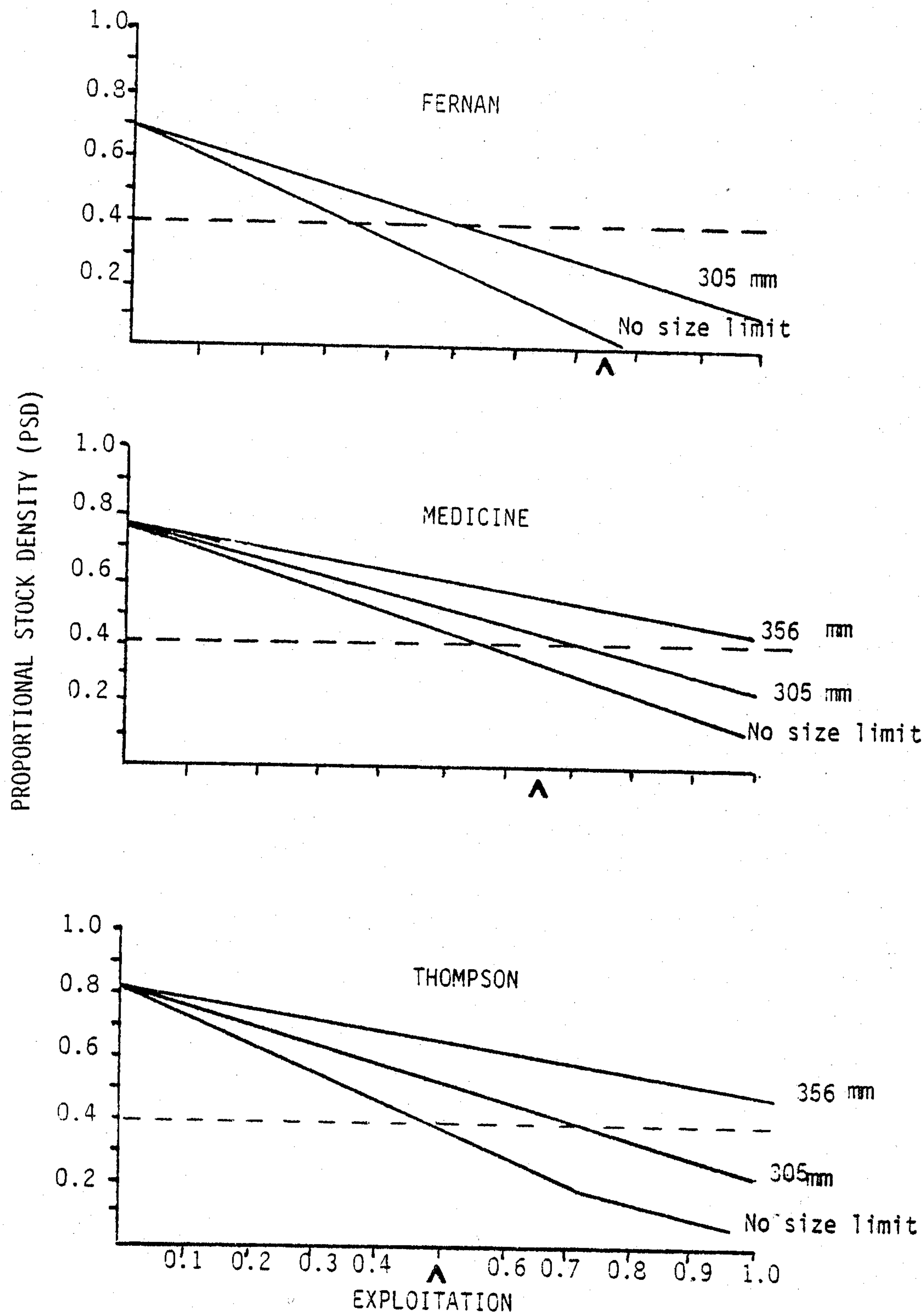

Figure 13. Proportional stock density (PSD) with varying levels of exploitation and size limits, predicted from the Ricker equilibrium yield model for bass in three lakes in north Idaho. Arrows indicate current exploitation.

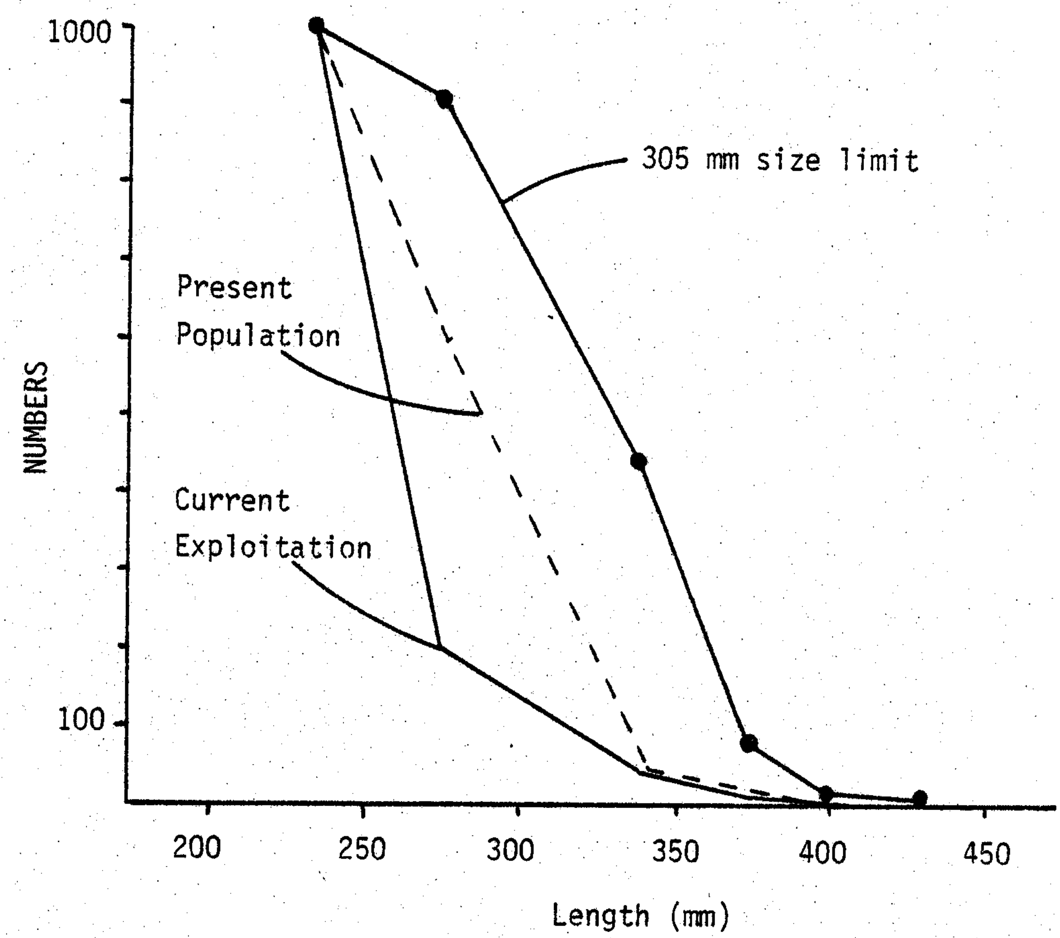

Figure 14. Population structure of bass in Fernan Lake at pre
in the future under current exploitation, and with a 305 m
limit, predicted from the Ricker equilibrium yield model.

In Thompson Lake, the 1982 data indicated significant numbers of fish in the population to 500 mm (Fig. 15). At the current exploitation rate of 0.6, the model population declined with few fish exceeding 450 mm. A 305 mm size limit provided an increase in the number of bass from 325 to 400 mm, but little or no improvement in numbers of large fish. A reduction in exploitation to 0.4 resulted in an increase in numbers of bass of all sizes. Combination of a 305 mm size limit and an exploitation of 0.4 increased the numbers of intermediate size bass dramatically.

Results of the model for Medicine Lake population structure were similar to those for Thompson Lake, though numbers of large bass tended to be greater in Medicine due to the higher growth rate (Fig. 16).

Temperature

Maximum-minimum temperatures in the upper one meter of the water column was similar among all the lakes and between years. Water temperature was lower during June and early July in 1981 due to unseasonably cold weather. The period of time when median temperature exceeded 10 C, often considered the growing season for largemouth bass, lasted from late April through October, or approximately 180 days (Fig. 17).

Tournaments

Two major bass tournaments were held on the Coeur d'Alene Lake system during 1981 and two during 1982. Results of the 1981 tournament evaluations are available in Rieman (1982). During 1982, a total of 529 bass were caught in tournament fishing (Table 16). The catch of tournament fish was spread throughout the system, but a major part of the catch came from the southern part (Hidden, Chatcolet, and Benewah lakes) and the main lake itself. Exploitation due to tournament fishing was estimated only on Thompson Lake, which was 4%. Proportion of the total harvest due to tournament fishing ranged from 4% to 26% (Table 16) on any lake.

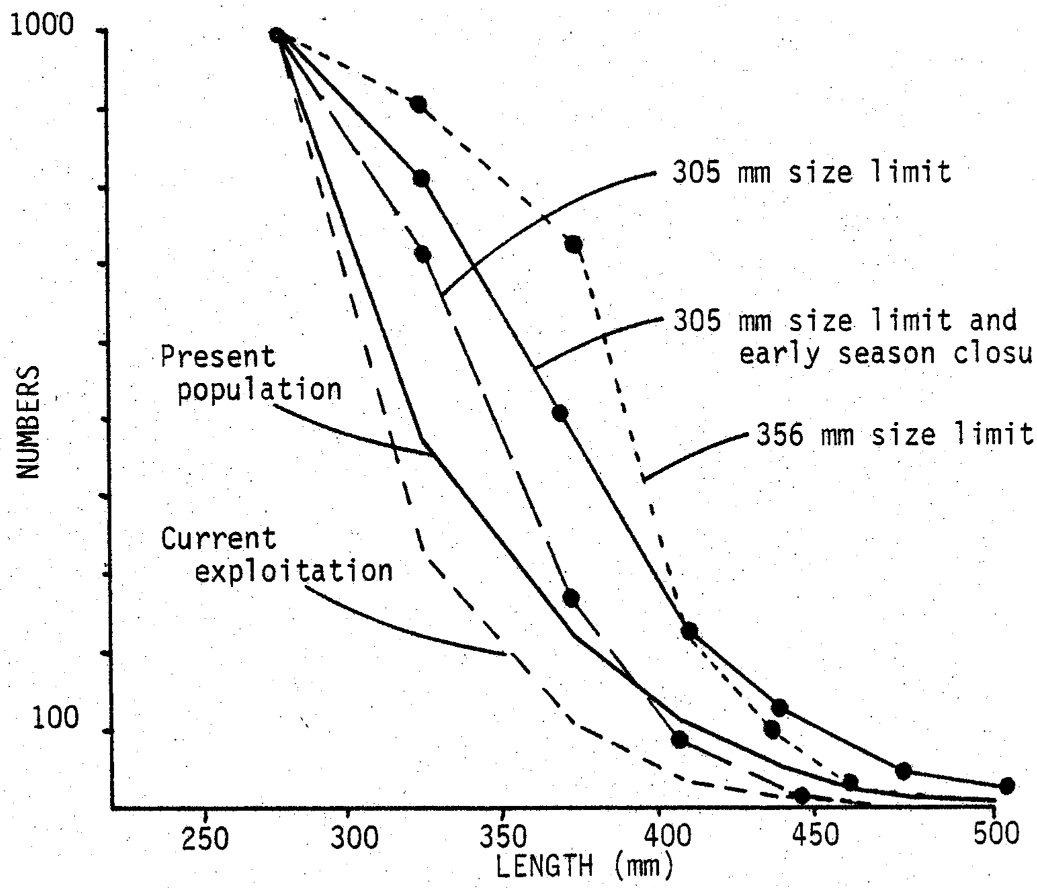

Figure 15. Population structure of bass in Thompson Lake at present, in the future under current exploition, with a 305 mm size limit, a 356 mm size limit, and with a combination of a 305 mm size limit and early season closure.

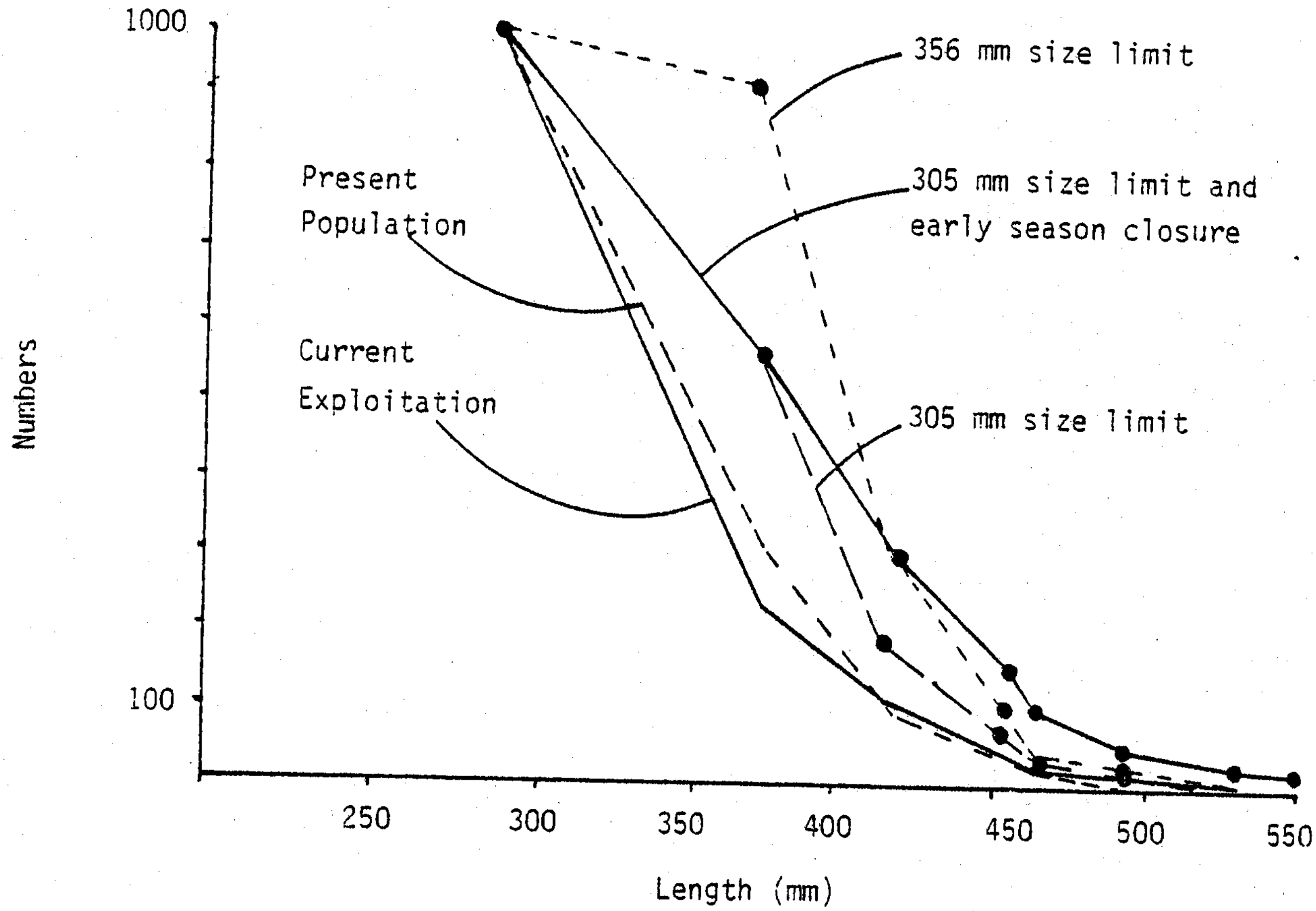

Figure 16. Population structure of bass in Medicine Lake at present, in the future under current exploitation, with a 305 mm size limit, a 356 mm size limit, and with a combination of a 305 mm size limit and early season closure.

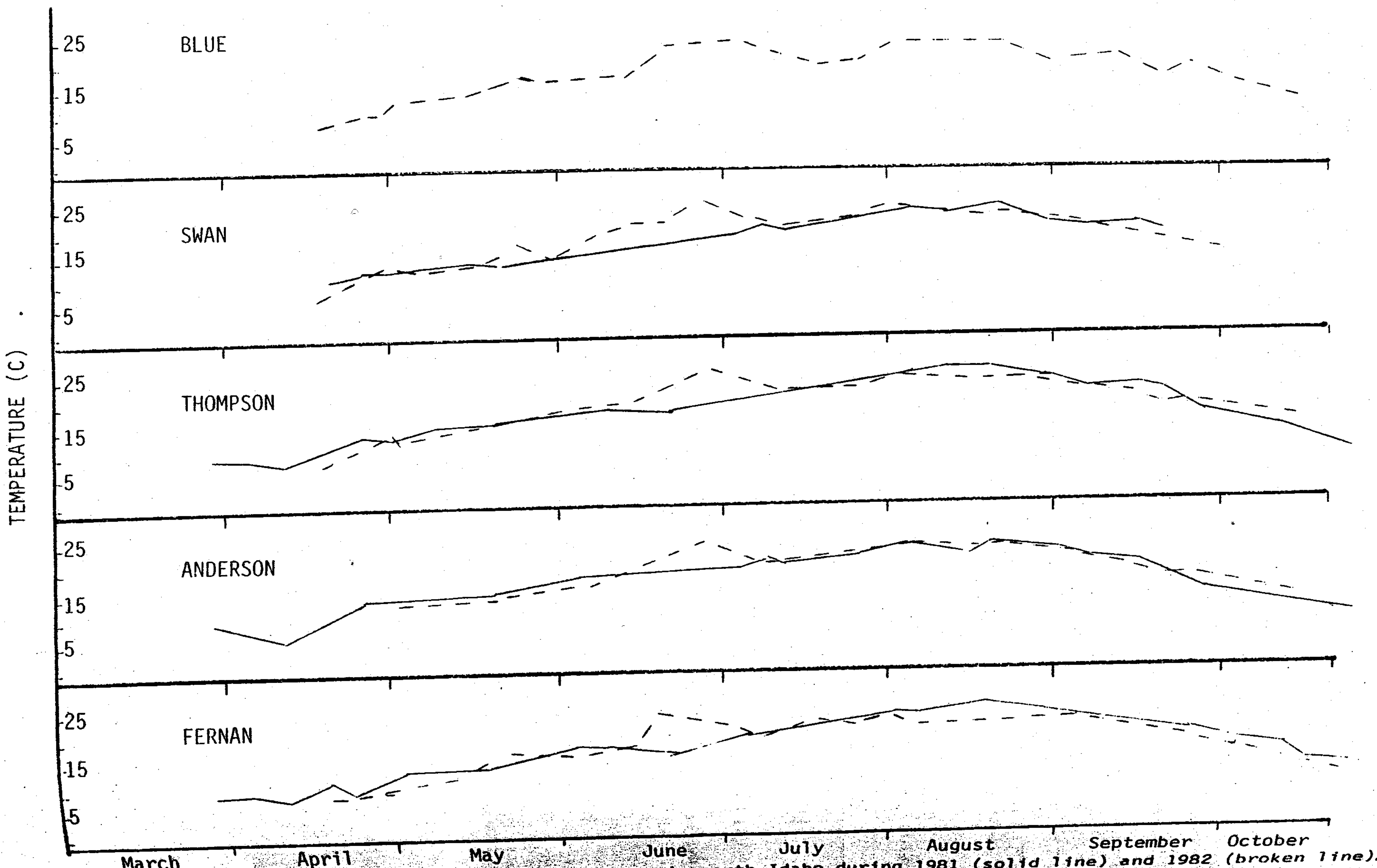

Figure 17. Mean surface temperature in five lakes in north Idaho during 1981 (solid line) and 1982 (broken line).

Table 16. Catch of bass during bass tournaments held on the Coeur d'Alene Lake system in north Idaho during 1982.

Lake	Thompson	Blue	Swan	Anderson	Black	Cave	Medicine	Lower Cd'A	Main Cd'A	Other	Total
TOURNAMENT											
August "Buddy"	13	14	20	38	11	61	4	99	42	5	307
September B.A.S.S.	16	13	5	14	12	6	6	49	47	20	188
Other	6	4	0	4	0	0	0	0	20	0	34
Total	35	31	25	66	23	66	10	148	109	25	529
Relative exploitation	4%	--	--	--	--	--	--	--	--	--	
Percent total harvest	4%	26%	10%	16%	--	--	--	--	--	--	

Following the August tournament, mortality of fish was 7% in a 14-hour period. Mortality was 1% in the same period following the September tournament. After both tournaments, we tagged and transported all live bass back to one of the study lakes. Following the August tournament, 20 bass were recovered dead from the release site. It is likely that the additional mortality was due to tagging and handling stress and not to initial hooking and release stress from tournament fishing alone. No delayed mortalities were recovered following the September transport and release. Water temperatures averaged around 25 C during the August tournament, but under 20 C in September.

During 1982, we continued to evaluate the dispersal of tagged bass released by tournament fishermen at Harrison in 1981. A total of 45 tag recoveries have been made following the release of 389 bass from tournaments in 1981 (Rieman 1982). Using a X^2 test, the distribution of recaptures (Table 17) did not show any dependence on origin ($\alpha = 0.3$). An analysis of dispersal assuming all three recapture areas were equally available was also made. When origin was considered separately the X^2 was not significant for either lateral lakes or south Coeur d'Alene fish at $\alpha = .05$, but was significant for south Coeur d'Alene fish at $\alpha = .10$.

DISCUSSION

Bass fishing success should be considered fair to good on all the study lakes except Blue. Catch rates for bass anglers ranging from 0.16 to 0.58 bass/hour fall roughly midway in the range of catch rates reported for North American waters (Carlander 1977). Harvest rates were considerably lower than catch rates, indicating a significant amount of catch-and-release fishing, but were still in an acceptable range. The low harvest and catch rates for Blue Lake suggest that the population there is at an unusually low density. The lack of success in our electrofishing on Blue supports such a contention.

Table 17. Redistribution of tournament-caught bass of two general origins from the Harrison release point in Coeur d'Alene Lake, Idaho, in 1981 and 1982.

Recapture location	Main Cd'A	South Cd'A	Lateral lakes	Home
Origin				
Lateral lakes	16	11	7	1
South Cd'A Lake	5	7	1	1

Though total catch and harvest rates were generally similar among the lakes, other measures of fishing quality varied. Harvest rate for bass $\geq$300 mm was much lower in Fernan Lake and Blue Lake than in other study lakes. Yield to the angler in grams/hour showed similar differences. Size of fish in the catch was also much lower in Fernan than any of the lateral lakes. If, as Anderson (1975) suggests, yield/hour and size of fish caught are more important measures of fishing quality than numbers, bass fishing on Fernan Lake would be considered much poorer than the lateral lakes.

Much of the difference in the quality of fishing is the result of difference in stock structure. In Fernan Lake, relatively few bass in our electrofishing samples exceeded 300 mm (PSD = 0.08-0.11) compared to the lateral lakes (PSD = 0.44 to 0.61). The difference in numbers of large fish can be attributed both to a higher mortality estimated in Fernan Lake and to a significantly lower growth rate.

Growth, measured by length and age, was relatively low for the study lakes when compared with more typical bass habitat. Growth was similar, however, to rates reported for Wisconsin waters located at a similar latitude. It is likely that growth in north Idaho bass is typical of that found for bass populations on the northern limits of the range. We did find a significant amount of variation in growth among the lakes, with Fernan being consistently lower than the other lakes. The cause for such differences is unclear. Water temperature, growing season, and density were not observed to vary in a trend consistent with growth. Finer differences in habitat such as early warming shoal areas or forage availability could be important. Crayfish are important in the diet of Fernan bass, while sunfish and perch predominate in the lateral lakes. Other work examining the actual productivity of the lakes is incomplete. The important point seems to be that differences in growth were consistent across all age classes and year classes. The data suggest that observed growth is characteristic of each lake and will be relatively consistent over time.

Results of the yield model indicate that growth can have a profound influence on the level of sustained yield for a particular lake. The difference in growth between Fernan Lake and Medicine Lake resulted in almost a two-fold difference in predicted yield/recruit at similar levels of exploitation. Growth also plays a significant role in the effect exploitation has on population structure. Current exploitation will virtually eliminate bass $\geq$300 mm in Fernan, but could provide a reasonable population structure in the other lakes. Because of this, it appears that the growth in each of the lakes is an important factor regulating quality of the fishery and the major factor regulating level of exploitation that can be sustained. Anderson (1975) reached a similar conclusion from analysis of Wisconsin and Oklahoma bass populations.

Estimates of natural mortality were quite low in the three lakes where data was available and it appears the exploitation was by far the major factor directly influencing total mortality. Our data indicate that fishing pressure can have a direct influence on population structure and fishing quality in north Idaho bass populations. Similar results have been observed in other bass fisheries (Goedde and Coble 1981, Anderson 1976, Davies et al. 1982, Latta 1975, Fox 1975).

Estimates of exploitation on the study lakes are relatively high (ranging from 48%-78%). Latta (1974) suggested that exploitation of largemouth rarely exceeds 35%, though other workers have indicated that on small ponds exploitation may reach 30%-70% in only a few days (Hickman and Congdon 1972). Our estimates of exploitation appear to be accurate. Estimated exploitation on individual lakes was relatively consistent from one year to the next. Alternative estimates based on tagging data are also corroborative. Exploitation estimated on tag returns was much lower than the original estimates, but is undoubtedly biased due to noncompliance. Our estimate of noncompliance was 67%, which is similar to literature values of approximately 60% (Folmar et al. 1980, Matlock 1981). If the tag estimates are corrected for noncompliance using a value in this range, they would fall very close to the exploitation estimated from harvest and population data.

There is some evidence that exploitation and resultant mortality in these populations has not been stable, but may be increasing. Catch curves for both Fernan and Medicine tended to be concave. Several factors influencing the population or the sampling could be important (Ricker 1975), but increasing mortality through time seems to be a likely cause (Rieman 1982). Our estimates of exploitation also exceeded some estimates of total mortality and there has been a general implication by the managers and fishermen of increasing fishing pressure in recent years.

If mortality is increasing as a function of fishing pressure and exploitation, composition of the stocks may change rapidly. Even if exploitation is maintained at the levels measured in this study, it is likely that abundance of large fish will decline. Results of the model indicate that both proportional stock density and relative abundance of large fish will decrease at current or higher exploitation. Indeed, concern voiced by local anglers suggests that reduced availability of large bass has already occurred. It is apparent that if either stock structure or yield is considered an important management criteria, current fishing pressure on the study lakes represents over-exploitation. Anderson (1976) suggests that a PSD ($\geq$300 mm) of 0.4 should be considered a minimum value for healthy bass populations. Fernan is already well below that point and our results indicate that the other lakes cannot maintain values above that at current exploitation. Equilibrium yield estimates also indicate that exploitation on each lake is well beyond the point for maximum production.

Results of the analysis suggest that regulation changes could influence stock structure and fishing quality. A 305 mm size limit could have a dramatic influence on yield in Fernan. Since the hypothetical regulation change involves only a change in size of fish kept and not fishing pressure, the increased total yield would also be equated with an increase in yield/angler hour, a definite measure of increased angling quality.

The results of a 305 mm size limit on the lateral lakes would provide some increase in yield (though not as dramatic as in Fernan) and could maintain a reasonable PSD with current exploitation. A 305 mm limit, however, would do little to maintain or enhance the numbers of large bass. More restrictive regulations such as a 356 mm size limit or a reduction in actual exploitation might be important.

The results of the yield model are obviously only theoretical projections of what might be expected to occur with regulation changes. Several major assumptions are inherent in the model. These include the following:

1. Growth in the population remains stable;

2. Natural mortality is constant;

3. Mortality due to catch-and-release fishing is negligible.

Our data indicate that growth within a lake is relatively stable though it may vary within individual year classes. Reduced growth as a density-dependent response to increased numbers could be a problem with a regulation change protecting some segments of the population. Stockpiling of bass under the minimum size limit with resultant stunting has proven to be a problem in southern waters (Keith 1978). Such reduction in growth could negate the potential increase in yield from a size limit. Similarly, a compensatory increase in natural mortality with declining fishing mortality could also result in a less-dramatic response in population structure. Very little is known of the compensatory nature of natural mortality in bass (Latta 1975). Our data indicate that some compensation may occur at low levels of fishing, but that natural mortality was quite low and stable where exploitations ranged from 60% to 80%. Further work on north Idaho bass populations experiencing low fishing pressure may be necessary to define this relationship.

Hooking or catch-and-release mortality can be important. If some fish under the minimum size die after being caught and released, the limit will obviously not be completely effective. Some estimates of hooking mortality have been high (30% to 40%) (Rutledge and Pritchard 1977, Seidensticker 1977). These estimates are for Texas waters, however, and appear to be considerably greater than what we may expect. We have observed hooking mortality associated with bass tournaments to range only from 1% to 8%. Similar hooking mortality rates have been observed in Washington (Fletcher 1981). Bass tournament fishing may stress fish even more than normal catch-and-release fishing since fish may be held in small live wells for several hours prior to release. It would appear then that hooking mortality may be a minor concern in north Idaho. The difference with the data from Texas may be due to lower water temperatures in our lakes. Our highest rates of hooking mortality were associated with August tournaments when water temperatures were at a maximum.

Failure in the model assumptions could lead to inaccurate projections of response to new regulations. The potential value of regulation changes may not be as good as they appear. For the most part, however, bass populations tend to meet the assumptions well and equilibrium yield models have often been used for evaluating population dynamics (Latta 1975, Anderson 1972, 1975, Sanders and Coble 1981). Estimated standing crops in the north Idaho populations (3-6 kg/ha) are also considerably below values (11-50 kg/ha) typical for bass (Anderson 1976, Jenkins 1975). It seems unlikely that our populations are approaching carrying capacities and that some increase in numbers would evoke compensatory response in population dynamics.

It is likely, then, that more restrictive regulations should provide results similar to that projected by the model. Results of experimental length limits on bass in other waters have been quite successful (Fox 1975, Rasmussen and Michaelson 1972, Johnson and Anderson 1972, Pelzman 1979, Paragamian 1982, Hoey and Redmond 1972, Latta 1975). Some problems of over-exploitation and reduced growth have occurred, but these are likely more pronounced in southern waters (Keith 1978).

Restrictive length limits not only appear to be useful biologically, they also appear to be socially acceptable. A strong majority of anglers on both Fernan and the lateral lakes said they would either support or strongly support more restrictive regulations such as size limits. Many of these anglers already practice catch-and-release bass fishing, as evidenced by catch rates that are considerably greater than harvest rates.

A reduction in total exploitation would require some regulation other than a length limit. On intensively-managed waters, harvest quotas may be maintained by strict monitoring and appropriate closures. Typically, season regulations and bag limits have also been used, but with varied success (Fox 1975). In north Idaho, a reduction in the bag limit would likely have little effect, since few anglers catch limits. A season regulation might prove more useful. A major part of the bass harvest occurs during the spring. As water temperatures rise, bass begin feeding actively. As spawning takes place in late spring and early summer, the fish become very agressive, territorial, and extremely vulnerable to angling. Fishing pressure also tends to be high with improving weather. As a result, more than 1/3 of the entire harvest on Thompson Lake occurred prior to the end of June. A closure of fishing during this period could have the effect of reducing the harvest significantly. The closure might only need to be in the form of early-season catch-and-release fishing with a later harvest season. Such a closure might be well supported by anglers. Local sportsmen's clubs have called for the closure of bass fishing during the spawning season. Although their concerns center around impacts to recruitment, rather than exploitation, the regulation could be the same. A major concern with this type of regulation centers around the potential for much increased fishing pressure with an opening day. Anglers may congregate on such lakes expecting higher densities of fish. The result might be a dramatic increase in pressure during the harvest season that could negate the effect of protecting fish earlier in the year.

Though our immediate interest in maintaining or enhancing the structure of bass populations is to provide the best fishery, there are other concerns. Balance between bass and their forage base is a classic problem in fisheries management (Anderson 1972, 1973, 1976; Swingle 1950; Carlander 1975; Davies et al. 1982). If the level of predation falls too low, forage populations may expand rapidly. The results may be stunted forage fish that support little fishing and may interfere with recruitment of juvenile bass through competition and predation. It is generally considered important to maintain adequate numbers of large bass, resulting in heavy predation on the forage base (Anderson 1973, Davies et al. 1982). During 1982, we began collecting data on population structure and growth for both perch and sunfish in several of the study lakes. Analysis of this information is far from complete, but there is some evidence that both perch and sunfish are very abundant and show signs of reduced growth. We also initiated an experiment on Thompson Lake to examine the effect of increasing numbers of large bass on the forage base. This work could provide further insight to the nature and significance of bass-forage problems in north Idaho, but will require several years of evaluation. At this point, we can only conclude that further decline in numbers of large bass due to over-fishing may result in more significant problems with predator-forage balance.

Tournament fishing made up a significant part of the total harvest in several lakes in both 1982 and 1981 (Rieman 1982). Exploitation due to tournament fishing alone, however, was relatively low on the lakes where estimates were possible in either year (Rieman 1982). The overall impact of tournament fishing was minor in both years. It is conceivable, however, that tournaments could have a more significant impact in the future. Fishing success was generally considered to be poor at the tournaments. Better weather conditions could have resulted in a dramatic increase in catch. Tournament anglers tend to concentrate on a few lakes. The southern lakes of the Coeur d'Alene system (Chatcolet, Benewah, Hidden) received a major part of the effort. That concentrating of anglers, coupled with good fishing conditions, could result in high exploitation on individual lakes.

On the basis of tag returns, bass displaced by tournaments did not exhibit a strong homing ability. Only two bass were recaptured in their lake of origin, while most fish tended to distribute randomly within the main lake. Because of the lack of homing, tournament fishing must be considered as actual harvest for any individual lake. The bass are not lost from the region's fishery, however. Tag returns in 1981 indicate that tournament-released fish contributed to later angler harvest at a rate similar to that for previously uncaught fish (Rieman 1982).

Tournament fishing can provide a useful management tool by making large fish available for transplant. We used 1982 tournament fish as part of an experiment to increase predation on a forage population. Similar work could be done to rehabilitate overfished or winterkill populations or establish new populations. Some caution should be used in transport. Seasonal timing may be important. We observed significant delayed mortality during August, but none in September. The additional stress may have been related to higher water temperatures during August.

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APPENDICES

Appendix A.

Recommendations for a General Evaluation of Idaho Bass Populations

Obviously, a wide range of biological and ecological information can be imporant in understanding a bass population and its fishery. A tremendous amount of research has been conducted on recruitment, production, trophic and forage relationships, competition, predation, and population dynamics. This kind of information can be very valuable, but generally requires lots of time, money, and manpower. Often, for the manager, a simple evaluation of the general status of a bass population can be more important than a complete understanding of the underlying dynamics of the system. The primary information necessary for evaluation of status is knowledge of stock structure. A number of population parameters and indices are readily available to fishery managers needing such information. They are listed and briefly discussed here in order of increasing importance, value, or usefullness, but decreasing order of availability or ease of attainment.

Proportional Stock Density

The proportional stock density index (PSD) is probably the simplest and most-easily available measure of stock structure that a manager can apply. PSD is usually calculated as the proportion of a sample of catchable-size fish (usually $\geq$200 mm) that is greater than 300 mm. Typically, a PSD of less than 0.4 would be considered indicative of bass stocks being overharvested or experiencing problems in recruitment or growth. PSD's in excess of 0.4 may be considered indicative of healthy fisheries (Anderson 1976). Data used to calculate a PSD is best collected by electrofishing during a period of time when size selectivity is not considered to be a major problem. For example, sampling during spawning may be biased toward large fish, producing a misleading, high PSD. The sample size necessary for reasonably-good confidence in an estimate of PSD should exceed 25 fish ($\pm$ 20%), while 50 ($\pm$ 12%) or 100 ($\pm$ 8%) fish is much better (Weithman et al. 1980). It is important to remember that the sample includes only fish in excess of the catchable size, usually considered as 200 mm.

Catch data may also be used to calculate PSD, but is much less useful. Because both anglers and their gear are selective for larger fish, the resulting PSD may not accurately reflect stock structure. High values of PSD calculated from such data are not very useful, though unusually low values (such as the 0.11 found on Fernan) may be considered strong evidence of a population in trouble.

PSD should not be considered as completely accurate even if a large sample size is used. Because of variation in year-class strength, PSD may fluctuate within a population even though mortality is stable. Several years of data can be very useful if it is available.

Age Structure and Mortality

Estimates of age structures from scale analysis can be useful in describing stock structure and estimating mortality. A representative length frequency of fish fully recruited to the catch is necessary. Normally, a sample of several-hundred fish is best, but samples with as few as 75-to-100 fish can be useful. It is not necessary to age all fish in the sample, but rather only a sub-sample (usually ten) of fish in each group. The age frequency in each length group is then used to estimate the age composition of the entire sample. Total morality is estimated from a catch curve and simple regression of the natural log of frequency on age. Bass tend to show a fair amount of fluctuation in year-class strength, which can result in a poor-fitting regression and an imprecise estimate of mortality. Several years of data can be very helpful for refining the estimate. Data for age composition can be used both from electrofishing and creel samples. The latter may be biased due to size selection, but that usually is not too much of a problem if mortality is calculated from the age of full recruitment to the fishery.

Mortality estimates may not be as easy to interpret as PSD estimates, since the proportion made up by natural causes may not be known. However, as a general rule in Idaho bass stocks, total mortality exceeding 50-60% on an annual basis may be cause for concern, while mortality in the range of 70-80% would almost certainly indicate some real problems.

Exploitation

Estimates of exploitation are obviously the key to understanding the importance of fishing pressure on the quality of fishing. By itself, an estimate of exploitation provides a minimum estimate of total mortality. Combining an actual estimate of total mortality and an estimate of exploitation, we can estimate fishing mortality and the relative effects of fishing on total mortality and population structure.

Exploitation can be estimated from total population estimates and total harvest estimates. This type of work typically requires a full-blown creel census and a mark-recapture population estimate, can be very time consuming and expensive, and is essentially impossible on large bodies of water. Estimates of exploitation by this method are also imprecise because of relatively-large sampling errors in creel data. Tag returns may also be used to estimate exploitation $\left(\frac{\text{number returned}}{\text{number out}}\right)$. Tag returns can provide a high degree of precision with a fair number of returns. However, tag returns usually represent a minimum estimate since they are biased by angler non-compliance. The estimates can be corrected using fudge factors from the literature (60% tags not reported), but these may be off due to local variation and the success of tag solicitation. Reward tags may offer an easy correction method in many areas. The idea is simply to mix in a sample of tags that provide a reward fee when returned (Henney and Burnham 1976). The tags are marked to inform the angler a reward is available on return. No notice of reward is made in the normal solicitation program to avoid creating artificially-high fishing pressure. If a significant reward ($5-$10) is offered, a high level of compliance (90-100%) may be assumed. The return rate of reward tags can be compared with normal tags to provide a corrected exploitation estimate. We are currently experimenting with a reward-tag system to determine the number and proportion of tags necessary for reasonable precision with minimal expense. With most of our systems and normal fishing pressure, it is usually a good idea to have more than 100 tags out. It is also important that tags be put out at the start of the fishing season or that some provision be made for estimating the relative amount of harvest (and thus exploitation) that occurred prior to tagging. The importance of exploitation on population dynamics can obviously be more or less important, depending on natural mortality and growth. For our populations, however, exploitation exceeding 50% may be cause for concern i management intent is to maintain reasonable numbers of large fish.

Yield Models

Equilibrium yield or dynamic pool models have proven to be extremely useful for evaluation of harvest regulations. A number of assumptions regarding density-dependent response of population are inherent in these models. However, for the most part, bass populations meet these assumptions very well. The models are simple in theory and require only data on growth and natural mortality. From that, the effects of varying exploitation rates and size limits on yield (total weight or weight/angler hour) and population structure (PSD, age-and-weight composition, standing crop) may be predicted. Growth must be estimated as length-weight relationship. Natural mortality can be estimated from total fishing mortality or simply from assumed values and other similar populations. As data becomes available on more northwest bass populations, the latter method can probably become fairly accurate. Natural mortality also seems to be less important in affecting results and their interpretation than growth, so some error in estimates is tolerable. If the manager has some idea of the current level of exploitation, the yield models can provide a good idea of how things may change with new regulations. Obviously, the results may not be totally accurate and are dependent upon the assumptions and quality of the data, but they certainly represent a step toward more objective management. We currently have such a model available and running on the University of Idaho computer. Total analysis of a problem may take two hours and cost $2.00 of computer time.

A scenario for a typical bass management program might be as follows:

1. Normal monitoring of a population is maintained on an annual or biannual basis. Estimates of PSD and/or age structure and mortality are collected through electrofishing, creel census, or tournaments.

2. If some concern arises due to a low PSD, poor age structure, high mortality, or a stunted-forage base, more work may be initiated. More-intense electrofishing (two or three days) is conducted early in the spring to provide more-precise data on age structure, mortality and growth, and to tag a significant number of fish. Exploitation is estimated based on tag returns and corrected by other estimates of non-compliance or a reward-tag program. The data is summarized and analyzed using a yield model. Management alternatives can be formulated and evaluated based on hard data.

Obviously, initiation and maintenance of such a management program will require some time. However, depending on cooperation through local bass clubs and the availability of equipment, an annual monitoring program for any single population should require no more than two or three days of a biologist's time. A more intense investigation could be accomplished with an additional five-to-ten days.

Appendix B. Back calculated length at age (mm) and increment of growth for Fernan Lake, 1981.

Age class	Year class	N	1	2	3	4	5	6	7	8	9	10
II	1979	23	71	127								
III	1978	9	65	123	166							
IV	1976	64	59	122	179	221						
V	1975	9	65	137	194	239	276					
VI	1974	21	66	151	218	270	313	342				
VII	1973	7	65	138	205	263	316	351	376			
VIII	1972	6	65	132	195	248	290	325	355	387		
IX	1971	4	74	137	208	262	313	356	381	414	435	
X	1970	1	63	123	168	261	307	349	374	422	457	482
Weighted average length			64	130	189	238	304	343	370	400	439	482
Increment of growth			64	66	59	49	66	39	27	30	39	43
N			144	144	121	112	48	39	18	11	5	1
Standard deviation of length at age			15.8	22.2	26.0	31.7	30.3	28.9	29.8	31.0	20.5	0

Appendix B. Back-calculated length at age (mm) and increment of growth for Fernan Lake, 1982.

Age class	Year class	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
II	1980	31	58	127												
III	1979	63	68	128	178											
IV	1978	13	54	115	169	206										
V	1977	83	56	113	169	213	249									
VI	1976	7	63	144	200	248	290	312								
VII	1975	6	68	145	216	270	311	342	372							
VIII	1974	5	75	145	217	278	320	363	392	414						
IX	1973	5	65	138	200	253	302	337	367	391	415					
X	1972	5	76	150	204	253	295	334	366	397	424	446				
XII	1970	2	67	142	188	250	302	356	384	420	452	472	496	520		
XIV	1968	2	81	143	202	277	324	361	406	435	456	476	496	517	531	545
Weighted average length			62	124	178	224	264	339	377	406	429	458	496	519	531	545
Increment of growth			62	62	54	46	40	75	38	29	23	29	38	23	12	14
N			222	222	191	128	115	32	25	19	14	9	4	4	2	2
Standard deviation of ength at age			12.8	21.1	23.7	30.4	34.0	27.4	26.1	27.7	25.8	23.4	7.1	4.9	8.5	7.1

Appendix B. Back-calculated length at age (mm) and increment of growth for Thompson Lake, 1981.

Age class	Year class	N	1	2	3	4	5	6	7	8	9	10	11	12
I	1980	1	50											
II	1979	28	75	142										
III	1978	16	75	138	191									
IV	1977	133	67	142	233	287								
V	1976	28	63	129	209	263	301							
VI	1975	19	70	129	206	264	324	368						
VII	1974	4	71	137	186	249	321	365	397					
VIII	1973	4	64	138	216	284	321	372	418	450				
IX	1972	3	68	145	240	290	349	395	418	443	459			
X	1971	2	65	174	282	349	397	431	456	480	495	511		
XII	1969	1	75	151	294	337	372	399	435	462	484	500	519	532
Weighted average ength			68	139	224	281	317	375	419	455	475	507	519	532
Increment of growth			68	71	85	57	36	58	44	36	20	32	12	13
N			239	238	210	194	61	33	14	10	6	3	1	1
Standard deviation of ength at age			13.1	24.2	33.6	31.4	42.3	34.8	37.5	30.4	32.6	6.1	0	0

Appendix B. Back-calculated length at age (mm) and increment of growth for Thompson Lake, 1982.

Age class	Year class	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
II	1980	17	64	125												
III	1979	99	67	133	180											
IV	1978	33	80	154	210	244										
V	1977	49	69	142	229	289	336									
VI	1976	14	69	150	229	287	324	356								
VII	1975	17	68	125	200	263	322	367	399							
VIII	1974	7	66	125	193	263	322	372	402	421						
IX	1973	2	76	139	223	292	335	394	422	451	470					
X	1972	4	52	113	161	234	294	345	377	412	440	453				
XI	1971	1	72	195	288	320	359	400	428	445	469	481	500			
XII	1970	2	75	182	245	303	354	405	442	460	476	497	513	525		
XIV	1968	1	66	130	230	295	377	426	453	464	479	494	502	517	530	540
Weighted average length			69	138	201	271	330	367	403	431	460	473	507	522	530	540
Increment of growth			69	69	63	70	59	37	36	28	29	13	34	15	8	10
N			246	246	229	130	97	48	34	17	10	8	4	3	1	1
Standard deviation of length at age			14.7	25.6	39.2	35.7	31.2	32.2	32.5	30.5	23.7	26.5	18.5	25.4	0	0

Appendix B. Back-calculated length at age (mm) and increment of growth for Medicine Lake, 1981.

Age class	Year class	N	1	2	3	4	5	6	7	8	9	10	11
II	1979	69	82	162									
III	1978	10	70	140	201								
IV	1977	69	62	129	202	265							
V	1976	16	60	154	251	332	373						
VI	1975	8	78	148	237	300	349	379					
VII	1974	7	67	174	280	357	400	438	465				
VIII	1973	5	68	162	262	345	389	423	448	459			
IX	1972	2	74	171	289	360	400	424	450	470	488		
XI	1970	1	49	186	286	371	400	429	454	479	511	529	540
Weighted average length			71	148	220	290	377	413	457	464	496	529	540
Increment of growth			71	77	72	70	87	36	44	7	32	33	11
N			187	187	118	108	39	23	15	8	3	1	1
Standard deviation of length at age			15.8	29.1	39.9	47.0	34.8	39.8	20.4	20.8	30.7	0	0

Appendix B. Back-calculated length at age (mm) and increment of growth for Swan Lake, 1982.

Age class	Year class	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
II	1980	4	59	188												
III	1979	29	74	164	262											
IV	1978	12	76	167	241	309										
V	1977	17	64	136	218	304	357									
VI	1976	6	72	156	256	341	376	405								
VII	1975	4	69	165	291	373	438	459	478							
IX	1973	1	62	177	238	337	391	434	468	483	490					
XIV	1968	1	67	135	255	298	347	393	418	433	444	462	471	489	506	520
Weighted average length			70	159	248	318	373	424	466	458	467	462	471	489	506	520
Increment of growth			76	89	89	70	55	51	42	8	9	52	9	18	17	14
N			74	74	70	41	29	12	6	2	2	1	1	1	1	1
Standard deviation of length at age			15.4	32.1	40.7	40.3	39.5	35.7	30.0	35.4	32.5	--	--	--	--	--

Appendix B. Back-calculated length at age (mm) and increment of growth for Blue Lake, 1982.

Age class	Year class	N	1	2	3	4	5	6	7	8	9	10	11	12	13
II	1980	1	52	100											
III	1979	9	76	166	235										
IV	1978	16	77	156	233	298									
V	2977	16	67	140	227	300	353								
VI	1976	3	60	173	253	334	372	397							
VII	1975	3	66	122	181	270	352	391	420						
VIII	1974	2	64	127	225	304	365	408	432	455					
IX	1973	4	81	146	234	327	382	423	448	467	483				
XI	1971	1	68	177	242	353	420	458	482	501	518	537	550		
XIII	1969	1	96	197	305	363	395	427	455	476	495	508	519	530	540
Weighted average length			72	150	231	304	363	411	441	469	491	523	535	530	540
Increment of growth			72	78	81	73	59	48	30	28	22	32	12	5	10
N			56	56	55	46	30	14	11	8	6	2	2	1	1
Standard deviation of length at age			14.1	31.1	41.0	37.3	30.8	23.1	23.1	16.1	16.2	20.5	21.9	--	--

Appendix C. Results of analysis of variance and multiple comparisons[a] of length at age among three lakes in north Idaho during 1981.

Age	Lake	N	Mean Length	Standard Deviation	F
I	Fernan	143	63.7	12.59	10.80[b]
	Thompson	239	68.4	13.11	
	Medicine	186	70.9	15.81	
II	Fernan	143	129.5	22.20	21.26[b]
	Thompson	238	138.8	24.22	
	Medicine	187	147.9	29.08	
III	Fernan	121	189.2	26.00	43.49[b]
	Thompson	210	223.7	33.63	
	Medicine	118	220.1	39.94	
IV	Fernan	111	237.4	31.72	70.10[b]
	Thompson	194	281.2	31.42	
	Medicine	108	290.0	47.00	
V	Fernan	47	303.5	30.25	47.18[b]
	Thompson	61	317.5	42.28	
	Medicine	39	376.9	34.83	
VI	Fernan	39	342.7	28.90	31.40[b]
	Thompson	33	375.0	34.83	
	Medicine	23	412.8	39.82	

[a] A Fischers LSD was used to determine differences between lakes. The vertical bars encompass lakes that are not significantly different from each other.

[b] Significant at $\alpha = .05$.

Appendix C. Results of analysis of variance and multiple comparisons[a] of length at age among four lakes in north Idaho during 1982.

Age	Lake	N	Mean Length	Standard Deviation	F
I	Fernan	219	61.4	12.82	17.01[b]
	Thompson	246	69.2	14.70	
	Blue	56	71.9	14.07	
	Swan	74	70.3	15.36	
II	Fernan	224	123.6	21.13	43.13[b]
	Thompson	246	137.5	25.64	
	Blue	56	150.4	31.14	
	Swan	74	158.7	32.09	
III	Fernan	191	178.1	23.66	82.98[b]
	Thompson	229	201.0	39.21	
	Blue	55	231.1	41.00	
	Swan	70	248.1	40.71	
IV	Fernan	128	223.8	30.36	113.78[b]
	Thompson	130	271.2	35.70	
	Blue	46	304.4	37.29	
	Swan	41	318.2	40.25	
V	Fernan	115	264.6	34.02	142.91[b]
	Thompson	97	330.2	31.15	
	Blue	30	362.9	30.80	
	Swan	29	372.9	39.47	

[a] A Fischer's LSD was used to determine differences between lakes. The vertical bars encompass lakes that are not significantly different from each other.

[b] Significant at $\alpha = .05$.

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